ON THE

SATELLITES OF THE PLANET SATURN,

AND THE

ROTATION OF ITS RING ON AN AXIS.

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From the PHILOSOPHICAL TRANSACTIONS.

A

ON THE SATELLITES, &c.

IN my laſt Paper on the Planet Saturn, the principal object of which was to give an immediate account of the moſt intereſting phænomena that had occurred till the beginning of November, many things were left unnoticed for want of time to treat of them with ſufficient accuracy; but having now before me the whole ſeries of obſervations from the 18th of July till the 25th of December, 1789, I can enter into a proper examination, aſſiſted by ſuch neceſſary calculations as then could not conveniently be made.

One of the principal motives which have induced me to haſten this inquiry, is the frequent appearance of protuberant and lucid points on the arms of the ring of Saturn. I have mentioned before that ſuch phænomena had been reſolved by the ſituation of ſatellites that put on theſe appearances; but as my obſervations were continued near two months afterwards, and as I had from them corrected the epochæ of the old ſatellites, and improved the tables of the new ones, I found that, beſides many of theſe bright points which were completely accounted for by the calculated places of the ſatellites, there were alſo many more mentioned in my journal that would not accord with the ſituation of any of them.

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The queſtion then preſented itſelf very naturally, what to make of theſe protuberant points? To admit two or three more ſatellites by way of ſolving ſuch phænomena appeared to me too hazardous an hypotheſis; eſpecially as theſe lucid points, though ſome of them had a motion, did not ſeem willing to conform to the criterion I had before uſed of coming off the ring, and ſhewing themſelves as ſatellites. And yet a ſuſpicion of at leaſt one more ſatellite would often return; it was even conſiderably ſtrengthened when I diſcovered, by means of re-calculating with great preciſion the whole ſeries of obſervations, that in the beginning of the ſeaſon there had been ſome few miſtakes in the names of the ſatellites, when the obſervations of them were entered in the journal. In ſetting them right, which threw a great light upon the revolution of the 6th, and more eſpecially upon that of the 7th, I found alſo, that ſome of the obſervations which were entered by the name of the 7th ſatellite could not belong to that, nor to any other known one. It remained therefore to be examined whether there might not be ſufficient ground to ſuſpect the exiſtence of an eighth ſatellite.

In this ſituation of things, I thought it moſt adviſable to draw out the whole ſeries of obſervations in a paper, beginning at the 5th ſatellite, and thus gradually through the 4th, 3d, 2d, 1ſt, 6th, and 7th, to approach towards the center of Saturn; that it might appear at laſt what obſervations were left unaccounted for. By this means alſo it will be ſeen clearly with how ſcrupulous an attention the identity of every ſatellite has been aſcertained; and with a view to give the ſtrongeſt ſatisfaction in this reſpect, at leaſt one obſervation of each has been calculated for each night; and the place thus computed is

put

put down in the notes, that it may be compared with the obferved one.

To facilitate this comparifon, I have delineated a fcheme *, wherein the orbits of the fatellites are drawn in their due proportion. A few words will explain the conftruction and ufe of this figure, which, notwithftanding its fimplicity, is yet amply fufficient to afcertain the accuracy of every obfervation.

In each of the orbits, by way of marking them, is placed the fatellite to which it belongs, as it appeared to be fituated the 18th of October, 1789. The graduated circle is of ufe to find, by means of the tables, the apparent place of a fatellite for any given time; or, the apparent fituation of the fame fatellite being given, its real Saturnicentric place may be deduced from it. In the center of the fcheme is the planet Saturn, and its ring, expreffed by a line which reprefents the direction of its anfæ; or the ring itfelf, as it appeared in my telefcopes during the months of July, Auguft, September, October, and November, 1789. The five lines which are carried on parallel to each other ferve to convey the meafure of the planet, and its ring, to the orbits of the fatellites, as will be feen in feveral inftances that occur hereafter.

The graduated circle is divided into degrees, and begins to count from that part of every fatellite's orbit beyond the planet, which is intercepted by a plane paffing from the eye of the obferver, at rectangles to the ring, through the center of Saturn. Hence it follows, that the point of zero, or 360 degrees, is the fame with the geocentric place of the planet in thofe four parts of the orbit of the fatellite where the eye is in the plane of the ring, and where it appears the moft open; and that, in other places, it may be had by folving one fpherical triangle. This is to be underftood as relating only to

* See Tab. XIX. fig. 1.

the

the inner satellites; the 5th, or outermost, requiring a different reduction, on account of its deviation from the plane of the ring. Moreover, I am inclined to believe, that the surest way of observing the 5th, is to trust only to measures, taken with micrometers which give the distance and angle of position, except in such cases when the eye is nearly in the plane of this satellite's orbit, where the different reductions may be neglected, without bringing on any considerable inaccuracies. The order of the numbers by which 90 comes to the left, and 270 to the right, is taken from the motion of the satellites, as they appear to revolve in their orbits, when seen in telescopes of my construction; and which is also the real direction of their motion according to the order of the signs. But the points 360 and 180 must occasionally be changed in their denomination of north or south, according to the real situation of the plane of each satellite's orbit. At present, for instance, when the satellites are at 360, that part of their orbits in which we find them lies to the south of the center of the planet; but about the end of August, 1789, and afterwards, the orbits of the six inner satellites were differently situated; so that the same points then were turned towards the north. I need not remark, that the situation of these points was changed again when the earth passed through the plane of the ring, and that it will change, in the 5th satellite likewise, when we come to be in the plane of its orbit.

The calculations of the places of all the satellites have been made according to tables which are given at the end of this Paper. Their form being very simple, I thought it not amiss to communicate them, for the use of those who may wish to enter into a more particular examination of the following observations; or to follow the satellites in their orbits at any

future

future time. It will be proper to mention, that I have deduced the epochæ of all the seven satellites from my own observations, and they will be found to differ considerably from those which are given by M. DE LA LANDE, in the *Connoissance des Temps* for 1791. But I have not attempted to extend them farther than a few years backwards or forwards, as I am not in possession of any observations that could authorize me to undertake such a work. On the contrary, I am well convinced, that no tables will give us the situation of the satellites accurately, till we have at least established the dimensions of their elliptical orbits, and the motion as well as the situation of their aphelia. The epochæ for 1789, therefore, must be looked upon not as *mean* ones, but such as respect the orbits of these satellites in their situation during the time of the following observations; and the two preceding, and two following years, must be already a little affected with those errors which are the necessary consequence of our not knowing the required elements. I flatter myself, however, that the observations, which are delivered in this Paper, will serve as a beginning to a proper foundation for investigating them. The many conjunctions between the satellites, for instance, will undoubtedly throw some light on the situation and excentricity of their orbits; as it will be found, that the calculated places of these conjunctions require elliptical motions to bring the satellites to such appearances, which, in circular orbits, could not so accurately have taken place. Nor can we ascribe the disagreements to the fault of the observations, since a very few minutes will suffice to determine the time of a conjunction, which never lasts long. For this reason also, I have carefully avoided deducing my epochæ from conjunctions, even with the 6th

satellite,

satellite, which moves so rapidly that, at first sight, we might think those situations favourable.

The mean motion of the five old satellites, as being sufficiently accurate for my present purpose, I have taken from the above-mentioned tables of M. de la Lande; and those of the 6th and 7th, of course, are the result of my own observations.

The geocentric place of Saturn, whose complement is to be added, in order to reduce the Saturnicentric situation of the satellites to the apparent one, I have taken from the nautical almanac to the nearest minute; and, as I have always confined myself to a literal transcription of the observations from the original journal, all the memorandums which are necessary either to explain them, or to correct mistakes in the names of the satellites, are thrown into notes, that there may be no interruption in the succession of the observations.

Observations on the fifth satellite of Saturn.

1789, July 18. 20 h. 20′ (A). The supposed fifth satellite (B) 6° or 7° sp. (C) the ring (D).

July

(A) The time of my observations being sidereal, it is necessary to mention, that this relates only to the hours, minutes, and seconds, the day itself being that which is generally used by astronomers, beginning at noon, and ending the noon following. By this means there can never be a mistake which sidereal hour I mean to point out, as no two such hours can occur in the same astronomical night.

It will also be necessary to remark, that all the times are those shewn by the clock; which, by equal altitudes, has been found to lose very equally at the rate of 0″,4 *per* day; and to be 8′ 51″,5 too fast at midnight the 18th of July, 1789, which is the time on which my observations on Saturn commenced.

(B) The satellite itself not being known, it is here called the supposed fifth.

(C) By six or seven degrees south preceding the line of the ring, is meant,

that

July 23. 19 29. The 5th sp. at a great distance (E).

July 28. 22 37. By a figure in the journal, at a great distance np. (F).

Aug. 18. 21 11. The supposed 5th at a great distance 25° np. R. (G).

Aug. 28. 1 28. A line drawn through a large star north of Saturn, and passing between one pretty considerable star nf. and another ff. Saturn, leaves the supposed 5th satellite a little on the following side. By two figures in the journal, the 5th is at a great distance nf. ♄ . (H).

Aug. 29. 23 29. The supposed 5th is a very little preceding a line drawn from the large star of last night, through a very small star; and a good deal following a line drawn from the

that the satellite in the first place was at the preceding side of the planet; that is, in the semicircle from 180 to 360, which passes through 270 degrees. And in the next, that the situation of its orbit was such as to bring the satellite, at its proper distance, into a line drawn from the center of Saturn, making an angle of 6 or 7 degrees with the line of the ring, and declining towards the south.

(D) The calculated place for 20 h. 20′, shewn by the clock, corrected by —8′ 51″,5, and reduced to 12 h. 22′ 16″ mean time, is 245°,5 which, as no distance is mentioned, leaves it doubtful whether the observation was that of the 5th satellite, or of a fixed star.

(E) By calculation the situation is 268°,1; which agrees well enough for 11 h. 11′ 47″ mean time.

(F) 13 h. 59′ 38″ mean time gives 291°,5, which agrees with the distance and direction; but as the satellite was sp. the observation, which says np. must belong to some small fixed star.

(G) The calculation for 11 h. 11′ 27″ gives 27°,4 or at a good distance ff; therefore this was not the satellite, but a star.

(H) It appears from the calculation for 14 h. 48′ 29″ which gives 74°,2, and also from the following observations, that this was the real 5th satellite; and that, having once obtained its place, I kept it in view all the rest of the season.

B   first

firſt pretty conſiderable ſtar of laſt night, through the ſame very ſmall ſtar (I).

Aug. 31. 21 3. The 5th I take to be nf. ♄ at a good diſtance (K).

Sept. 8. 22 37. The 5th about 15° nf. R. and, by a figure, at a great diſtance (L).

Sept. 11. 20 11. The ſuppoſed 5th ſatellite and two ſmall ſtars ſf. a ſtar *x*, which is ſf. ♄, form an exact line.

22 32. The ſuppoſed 5th, and the two S ſt. ſf. *x*, form no longer a line; ſo that is the real fifth ſatellite.

Sept. 11. 23 52. The 5th ſatellite keeps advancing; its ſituation is 20 or 22° nf. the line of the R. and, by a figure, it is at a conſiderable diſtance (M).

Sept. 13. 22 17. The 5th ſat. of the 11th of Sept. is advanced, and is now north preceding a conſiderable large ſtar, which was that night ſp. ♄. By a figure it is nf. ♄, at a conſiderable diſtance (N).

Sept 14. 20 33. The 5th a little nearer than laſt night (O).

22 30. The 5th ſat. of Sept. 11. obſerved at 20 h. 11', has left the place where it was at that time.

Sept. 16. 19 39. The 5th is drawing nearer towards its conjunction.

22 18. Much the ſame as before.

23 59. About 33° north following the direction of the R. (P).

1 3. The 5th nearly as before.

	h.	′	″	°			h.	′	″	°
(I)	12	45	53.	78,4.		(K)	10	12	26.	87,2.
(L)	11	14	47.	124,2.		(M)	12	17	48.	138,3.
(N)	10	35	13.	147,2.		(O)	8	47	34.	151,5.
(P)	12	5	9.	161,3.						

Sept.

Sept. 17. 19 48. The 5th fat. of ♄ 30° nf. R. and at the diſtance of about 3 dia. of R. (Q).

Sept. 18. 21 15. About 2 dia. of R. and near 40° north following (R).

Sept. 20. 23 24. The 5th fat. is within a degree of its conjunction. It is north of ♄, and its motion is retrograde.

23 54. A perpendicular from the 5th fat. to the ring of Saturn, falls towards the following ſide ſhort of the center by $\frac{1}{4}$ dia. of ♄.

0 19. Diſtance of the 5th ſatellite from the parallel of the R. of ♄, 3 rev. 36,7 parts = 1′ 0″,966 central meaſure.

1 25. The 5th very nearly central.

1 28. With a power of 240, perfectly central. With 300, perfectly central (S).

Sept. 21. 21 15. The 5th fat. is perpendicular to a place half a projection of the ring preceding the edge of it (T).

Sept. 23. 22 51. At a conſiderable diſtance np. ♄ (V).

Sept. 24. 19 56. At a good diſtance np. ♄ (W).

Sept. 25. 19 34. The 5th purſues its track (X).

	h.	′	″	°		h.	′	″	°
(Q)	7	50	55.	165,1.	(R)	9	13	45.	170,0.
(S)	13	18	13.	180,0, or directly at rectangles to the ring, to the north.

I have uſed this obſervation for ſettling the epocha of this ſatellite, in which I have made no other allowance than that of the geocentric place of Saturn, as I knew this would anſwer all my purpoſes. But when we would obtain the mean motion of this ſatellite in comparing its preſent place with other ſituations at a great diſtance of time, proper reductions of the geocentric place of ♄ to the orbit of this ſatellite ſhould be made. This may, however, be done much better when the real ſituation of its orbit is properly aſcertained.

	h.	′	″	°		h.	′	″	°
(T)	9	1	59.	183,8.	(V)	10	29	52.	193,3.
(W)	7	31	25.	197,4.	(X)	7	5	33.	201,9.

Oct.

Oct. 12. 21 18. The suppofed 5th forms nearly an ifofceles triangle with two preceding ftars, the fouthern one of which is double, confifting of a very confiderable ftar and a fmall one. By a figure, at a confiderable diftance, np. ♄ (Y).

Oct. 15. 21 1. The large ftar of the double ftar in the figure of the 12th of Oct. is gone from its place, and the fuppofed 5th of that night is left (Z).

21 8. The real 5th is fo bright this evening, and was fo the 12th of Oct. that I miftook it on that account for a confiderable ftar; it was then nf. ♄. By three figures to-night it is at a great diftance np. ♄. I faw it move to-night; for at 21 h. 1′ it made an angle of 50° on the following fide with three ftars in a line, fp. ♄. At 1 h. 9′, that angle was lefs than 40°; and at 1 h. 41′, it was no more than about 35°.

Oct. 16. 20 16. The 5th now precedes a line drawn through the three ftars which it followed laft night at 21 h. 1′. By five figures, at a great diftance fp. ♄ (A).

Oct. 18. 20 18. At a great diftance fp.

21 51. At 7 or 8′ diftance fp. The fame by two figures (B).

Oct. 20. 20 50. By three figures, at a great diftance fp. (C).

Oct. 28. 21 1. The 5th about $3\frac{1}{2}$ dia. of ♄ diftant, and 45° fp. (D).

Oct. 29. 21 49. The 5th fat. of ♄ is approaching towards its oppofition (E).

(Y) 7 h. 42′ 32″. 280°,3. The diftance and fituation agree well enough, but not the angle, which, by what will appear hereafter from the fituation of the nodes of this fatellite, fhould be f p.

	h.	′	″	°		h.	′	″	°
(Z)	7	13	49.	294,0.	(A)	6	25	0.	298,4.
(B)	7	51	54.	307,9.	(C)	6	43	13.	316,8.
(D)	6	22	47.	353,4.	(E)	7	6	44.	358,1.

Oct.

Oct. 30. 20 53. The 5th fat. is paft the oppofition a little more than yefterday it wanted of it (F).

Oct. 31. 21 13. The 5th about 3½ diameters of Saturn ff. (G).

21 43. It is very faint; fainter than the firft; not much brighter than the fixth (H).

Nov. 2. 23 57. By a figure, the 5th fat. at fome diftance ff. (I).

Nov. 3. 22 1. At a good diftance ff. R. (K).

22 13. The 5th a little following a line drawn through two fixed ftars and between them. It is fouth of the ring.

Nov. 4. 22 17. The 5th at a great diftance following, and a very little fouth; it precedes the line of the two ftars which it followed laft night (L).

Nov. 7. 22 9. The 5th at a great diftance following, and a little north (M).

Nov. 8. 20 46. At a great diftance following (N).

Nov. 10. 23 30. As the calculation gives it (O).

(F) 6 h. 6' 57''. 2°,5.   (G) 6 h. 22' 59''. 7°,1.

(H) From the confiderable change in the light of this fatellite, we may furmife, that it has a revolution upon its axis; the fituation (fee note Z and G), which affects the apparent brightnefs, fhould however be taken into the account.

(I) 8 h. 58' 41''. 16°,8.   (K) 6 h. 59' 4''. 21°,0.

(L) 7 h. 11' 6''. 25°,2. A few days ago I perceived, that in the former part of thefe obfervations I had omitted a pretty effential circumftance, which is an attention to the nodes of the 5th fat. with the ring of Saturn.

(M) 6 h. 51' 21''. 39°,2. It appears from this and the foregoing obfervation, that the afcending node of the 5th fatellite, with regard to the ring of Saturn, apparently lies between the 25th and 39th degrees, which, reduced to a Saturnicentric pofition, is about the 19th degree from the point Aries reckoned upon the ring.

(N) 5 h. 24' 39''. 43°,5.   (O) 8 h. 0' 21''. 53°,0.

Nov.

Nov. 13. 22 33. On the following side (P).

Nov. 15. 22 33. By a figure, nf. Saturn at a great diſtance (Q).

Nov. 19. 22 15. Diſt. of the 5th. ſat. 1ſt meaſure 8 54,94
but too ſmall.

22 28.	—	—	2d	—	8 58,28
22 43.	—	—	3d	—	8 58,23
22 54.	—	—	4th	—	8 58,85

Mean of the three laſt meaſures 8′ 58″,45.

This, when the exact inclination of the orbit is aſcertained, muſt be brought to the greateſt elongation, and alſo reduced to the mean diſtance of the planet from the ſun.

Dec. 2. 0 56. The 5th ſat. is in its calculated place (R).

Dec. 5. 0 10. As the calculation gives it (S).

Dec. 16. 23 59. At a great diſtance preceding (T).

Obſervations on the fourth ſatellite of Saturn.

July 18. 19 50. The 4th ſatellite is about 6 or 7° np. R. (A).

July 23. 19 29. About 3½ dia. of ♄ following the body (B).

	h. ′ ″	°		h. ′ ″	°
(P)	6 51 44.	66,5.	(Q)	6 43 53.	75,6.
(R)	7 59 46.	152,8.	(S)	7 2 7,	166,2.
(T)	6 7 58.	215,4.	(A)	11 52 21.	284,0.
(B)	11 11 47.	36,4.			

Following or preceding the *body*, denotes that we are to reckon from the neareſt part of the circumference, and not from the center; but it is alſo to be obſerved, that eſtimations in diameters, when they exceed one, or one and an half, are not intended as meaſures, but merely to point out the ſituation in a very coarſe way; ſo that we are to look upon the calculation as not diſagreeing with this eſtimation, though we ſhould find the ſatellite conſiderably farther from the body.

July

July 27. 20 27. 4 or 5 dia. following (C).

July 28. 19 40. Near 4 dia. following (D).

Aug. 18. 21 11. Many dia. preceding (E).

Aug. 28. 0 14. About 4½ dia. of ♄ following the body (F).

Aug. 29. 22 18. 3 dia. of ♄ following the body (G).

Aug. 31. 20 48. About 2½ dia. of ♄ p. the body; a few seconds farther off than the 2d satellite, and a little south of it (H).

Sept. 8. 22 30. About 2½ dia. of ♄ following the body (I).

Sept. 10. 19 42. Following Saturn (K).

Sept. 11. 20 26. Following ♄, too far to estimate by the diameter (L).

Sept. 13. 22 17. By a figure, at a distance following (M).

Sept. 14. 20 33. About 1½ dia. of the ring following (N).

0 42. 1½ dia. of R. f. the edge.

1 24. 1 dia. of R. f. the ring; exactly in the line.

Sept. 16. 19 37. Not quite 1 dia. of the ring preceding (O).

22 15. 1½ dia. of R. p. the edge, and a little south.

23 59. Near 1½ dia. of R. preceding the edge of the ring.

Sept. 17. 19 48. About 3 dia. of the ring p. the projection (P).

Sept. 18. 21 15. Almost at its greatest distance p. (Q).

	h. ′ ″	°		h. ′ ′	°
(C)	11 53 55.	127,5.	(D)	11 3 7.	149,3.
(E)	11 11 27.	264,7.	(F)	13 34 42.	133,4.
(G)	11 35 5.	154,2.	(H)	9 57 29.	198,0.
(I)	11 7 48.	20,3.	(K)	8 12 24.	62,8.
(L)	8 52 22.	86,1.	(M)	10 35 13.	133,0.
(N)	8 47 34.	154,0,	(O)	7 43 52.	198,3.
(P)	7 50 55.	221,1.	(Q)	9 13 45.	245,0.

Sept.

Sept. 20. 23 24. At a great diftance p, and a little n. (R).

o 40. I can fee the 4th fatellite of Saturn without an eye-glafs in the 20-feet fpeculum by drawing back the eye about three or four feet.

21. Sept. 21 15. At a good diftance preceding, and a little north (S).

Sept. 23. 22 33. The 4th fatellite emerged a few feconds ago. It is now in the line of a tangent to that part of Saturn where the projection of the ring comes from the body (T).

22 51. $\frac{1}{3}$ of the projection (V) following the body of ♄; and about 2 of its own diameters north of the ring; or not quite half way northwards between the center of ♄ and the northern limb.

Sept. 24. 19 56. About 2 of its own dia. nearer the ring than the 3d fat. and a little more north.

20 48. The 4th advances to its conjunction with the 3d.

22 47. The 4th is paft by the 3d. By a figure, it is lefs than one of its diameters paft the 3d fatellite, and is more north than the 3d (W).

Sept. 19 34. It purfues its track (X).

Oct. 12. 20 37. At a great diftance following (Y).

Oct. 15. 20 54. Many diameters of Saturn f. (Z).

23 20. The 4th fat. at a confiderable dift. f.

	h.	′	″		°		h.	′	″		°
(R)	11	14	33.		292,2	(S)	9	1	59.		312,8.
(T)	10	11	55.		359,2.						

(V) The diftance from the body of Saturn to the end of the projecting part of the ring, I call the projection, and have made ufe of it as a meafure for eftimating.

	h.	′	″		°		h.	′	″		°
(W)	10	21	57.		22,0.	(X)	7	5	33.		41,6.
(Y)	7	1	39.		66,5.	(Z)	7	6	50.		134,4.

Oct.

Oct. 16. 20 16. 2½ dia. of ♄ following the body.

21 59. The colour of the 4th satellite is red, or inclining to red; it approaches towards a conjunction with the 3d.

0 9. The 4th is very nearly in conjunction with the 3d; it is about ¼ of its own dia. nearer to Saturn than the 3d, and near one dia. of the 3d satellite more south than the 3d (A).

Oct. 18. 20 18. 2½ dia. of ♄ p. the body.

21 51. About 2½ dia. of ♄ preceding (B).

Oct. 20. 20 50. At a great distance preceding (C).

Oct. 28. 21 1. At a great distance following (D).

Oct. 29. 21 49. At a good distance ff (E).

Oct. 30. 20 53. At a great distance following (F).

Oct. 31. 21 13. At a considerable distance following (G).

Nov. 2. 21 6. The 4th sat. is invisible.

21 51. I cannot see the 4th satellite (H).

22 53. The 4th sat. is not visible; I looked for the shadow of it upon ♄, but could not perceive it. The weather a little hazy.

23 21. Upon the dark equatorial belt of ♄, on the f. side, near the edge of the disk, seems to be a small black spot which is darker than the rest of the belt.

	h. ′ ″	°		h. ′ ″	°
(A)	10 17 22.	160,1.	(B)	7 51 54.	203,0.
(C)	6 43 13.	247,2.	(D)	6 22 47.	67,9.
(E)	7 6 44.	91,2.	(F)	6 6 57.	112,8.
(G)	6 22 59.	135,7.			

(H) The tables I used at the time of this observation being different from my present ones, I expected the 4th satellite to be past its conjunction, and consequently visible again.

C

23 29.

23 29. A protuberance on the sp. part of ♄; I suppose it to be the 4th satellite emerging.

23 31. The black spot upon the equatorial belt seems to be a little advanced towards the preceding side.

23 38. With 300 the satellite is very nearly detached; the black spot keeps advancing; it is a very little north of the equatorial belt, but part of it is upon the belt.

23 43. The black spot is a little more than $\frac{1}{7}$ of the dia. of ♄ advanced from the f. side towards the center.

23 46. The satellite seems to be detached.

23 47. With 300, it is detached; and the black spot keeps advancing.

23 57. The black spot is advanced so as to be $\frac{1}{3}$ of its way towards the center; the 4th satellite is near $\frac{1}{4}$ its own dia. clear of the edge.

0 13. The black spot a little more than half way towards the center; it is much darker than the belt.

0 34. The black spot is not arrived to the center yet.

0 53. The black spot is not come to the center, but does not want much of it.

0 57. It is more upon the belt than it was before; that is, more south.

1 6. The black spot is not yet come to the center.

1 10. It is drawn towards the south, so as to be nearly in the middle of the equatorial belt.

1 11. It is not far from a central position.

1 15. It is not come to the center yet.

1 18. The black spot is very near central.

1 21. Very near central.

1 25. Begins to be in the center.

1 30.

1 30. It is in the center (I).

Nov. 3. 22 1. The 4th fat. about 3 dia. p. the body (K).

Nov. 4. 22 17. At a confiderable diftance preceding (L).

Nov. 7. 22 9. At a good diftance preceding (M).

Nov. 8. 20 46. At a good diftance p. (N).

Nov. 10. 21 3. The 4th satellite not yet vifible.

21 32. Not yet vifible.

22 26. Not yet vifible.

23 24. About ½ dia. of ♄ nf. (O).

Nov. 13. 22 33. On the following fide (P).

Nov. 15. 22 33. Following ♄ at a good diftance (Q).

Nov. 26. 0 28. The 4th satellite is emerged fome time paft.

0 30. It is nearly in conjunction with the 6th. By a figure, it is half the diameter of the 6th nearer to Saturn than the fixth, and north of it (R).

Nov. 30. 23 36. Dift. of the 4th fatellite   3′ 12″.379.

     23 42.   2d meafure   —   3 10 .972.

     23 52.   3d —   —   3 10 .494.

     23 59.   4th —   —   3 10 .579.

Mean of the four meafures 3′ 11″.106 (S).

                                                 Dec.

(I) 10 h. 31′ 25″,5.   184°,8.   An extract of thefe obfervations being printed in my laft Paper, I am to remark, that here the time is uncorrected; but the correction for this evening being —8′ 8″,7, it will be feen, that in the former Paper —8′ has been applied to all the times, and —8′ 9″ to the time of the exact conjunction.

	h.	′	″	°		h.	′	″	°
(K)	6	59	4.	204,1.	(L)	7	11	6.	226,9.
(M)	6	51	21.	294,4.	(N)	5	24	39.	315,6.
(O)	7	54	22.	3,1.	(P)	6	51	44.	69,9.
(Q)	6	43	53.	115,0.	(R)	7	57	23.	4,4.

(S) The middle of the time to which we may fuppofe the meafures to anfwer

                                                    is

Dec. 2. 0 56. In its calculated place (T).

Dec. 5. 0 10. As the calculation gives it (V).

Dec. 16. 23 59. At a great diftance following (W).

0 43. The 4th fatellite, with a power of about 500, fhews a pretty confiderable, vifible difk (X),

Obfervations on the third fatellite of Saturn.

July 18. 19 50. The 3d fatellite about 1 or 2° ff. R. By a figure, at a confiderable diftance (A).

July 23. 19 29. Near 2 dia. of ♄ following (B).

July 27. 20 27. About 2½ dia. of ♄ following (C).

July 28. 19 40. The 3d fat. ½ dia. following ♄; it is much larger than the 2d, and a little more north.

22 34. ⅓ part of a dia. following (D).

Aug. 18. 21 11. 1½ dia. of ♄ following the ring (E).

Aug. 28. 0 14. Full 2 dia. f. ♄ (F).

is 23 h. 48″, or 6 h. 59′ 48″ mean time. And by computation the apparent place of the fatellite at that time was 93°,778, which is 3°,778 or 3° 46′ 41″,52 paft the greateft elongation; therefore its diftance, if it had been meafured at the greateft elongation, would have been 3′ 11″,522. This quantity brought to the mean diftance of Saturn from the fun, amounts to 3′ 8″,918.

	h.	′	″	°			h.	′	″	°
(T)	7	59	46	139,8		(V)	7	2	7	206,6
(W)	6	7	58	93,6						

(X) And from its ruddy colour (fee Oct. 16.) we may furmife it to have a confiderable atmofphere. This fatellite, therefore, feems to approach more to to the condition of a planet than any of the fourteen known fatellites.

	h.	′	″	°			h.	′	″	°
(A)	11	52	41	85,5		(B)	11	11	47	121,9
(C)	11	53	55	83,1		(D)	13	56	39	169,6
(E)	11	11	27	35,0		(F)	13	34	42	120,6

Aug.

Aug. 29. 22 21. A satellite on the edge of the preceding arm (G).

23 1. The sat. a very little separated from it. I suppose it to be the 3d, on account of its size and brightness.

23 41. The satellite is now fully detached, so as to be near ⅓ of the projection preceding the end of it.

Aug. 31. 20 56. The preceding arm, about the middle, seems to be charged with a satellite; power 157 (H).

21 3. With 300, the same as before.

Sept. 8. 22 30. The 3d sat. about 2½ or 3 dia. of Saturn p. the body (I).

Sept. 10. 19 42. The 3d following Saturn (K).

Sept. 11. 20 26. 1½ dia. of ♄ f. the body of ♄.

22 36. 1 dia. of ♄ f. the body.

0 16. The 3d a little less than the projection from the f. edge.

0 34. ¾ of the projection following the ring.

1 57. A little less than ½ the projection f. the ring (L).

Sept. 13. 22 2. The 3d, 1¼ dia. of R. preceding the edge of R. (M).

Sept. 14. 20 27. The 3d sat. ½ the projection f. R. (N).

21 55. 1½ of the projection f. and a very little north.

0 42. 2 projections following.

1 24. Near two projections following.

Sept. 16. 22 18. (O).

	h.	′	″	°			h.	′	″	°
(G)	11	38	5.	193,9.		(H)	10	5	27.	348,3.
(I)	11	7	48.	269,9.		(K)	8	12	24.	59,7.
(L)	14	22	27.	159,9.		(M)	10	20	15.	306,1.
(N)	8	41	35.	20,4.						

(O) 10 24 26. 185,6. By this it appears that the 3d satellite was invisible; but observations being made on a satellite, by mistake supposed to be the third, they will be found among those of the 6th, to which they belong.

Sept.

Sept. 17. 19 48. The 3d fat. 1¼ dia. of the ring preceding the projection (P).

Sept. 18. 21 15. ¾ of the projection, or 1½ dia. of the fatellite preceding the edge of the ring.

21 45. ¼ of the projection preceding R.

21 53. The 3d almoft touches the R.

21 59. Quite clofe to the ring, and a little north.

22. 7. Not quite fo near but that I can ftill fee a fmall divifion.

22 20. With 157, I can no longer fee a divifion between the 3d fatellite and the R.

22 22. With 300, the fat. is completely joined to the R. but fo as to make it appear a little longer, and a very little knotty towards the north (Q).

Sept. 20. 23 27. The 3d fat. 1½ projection f. R. It is within lefs than the diameter of the 2d fatellite preceding the 2d, and a little more fouth (R).

23 51. The 3d fat. is now more feparated from the 2d.

0 45. 1¼ projection f. R.

1 22. 1 projection f. R.

Sept. 21. 21 15. 2½ projections preceding the edge.

22 44. Near 3 projections p. R. (S).

Sept. 23. 22 51. The 3d fat. 1 projection f. the edge (T).

Sept. 24. 19 56. 1½ dia. of R. f. the edge; about 2 diameters of the 4th fatellite farther from R. than the 4th, and a little more fouth.

20 48. It advances towards a conjunction with the 4th.

	h.	′	″	°		h.	′	″	°
(P)	7	50	55.	256,9.	(Q)	10	20	34.	345,0.
(R)	11	17	33.	147,6.	(S)	10	30	44.	224,8.
(T)	10	29	52.	24,3.					

22 47. It is paft by the 4th. By a figure, it is about half its own diameter paft the conjunction, and is more fouth than the 4th (V).

Sept. 25. 19 34. (W).

Oct. 12. 20 37. The 3d fat. about 3½ dia. of ♄ f. the body (X).

Oct. 15. 20 47. 1¼ dia. of ♄ p. the body.

21 30. A little more than 1 dia. of ♄ from the body; and its whole diameter north of the line of the projection.

22 25. The 3d fat. will be in conjunction with the 6th, in a very fhort time, the 3d being ftill a little preceding.

22 39. The conjunction is fo complete now, that I have loft the 6th. The 3d, however, appears to be a little length-ened out towards the fouth. Diftance from the body barely one diameter of ♄; or juft one dia. of ♄ including the dia. of the 3d (Y).

23 54. Near two of its own diameters paft the conjunction with the 6th.

0 59. The 1ft, the 3d, and the 6th, are at equal diftances from each other.

1 14. The 3d is nearer to the 1ft than to the 6th.

1 35. The 3d approaches to a conjunction with the 1ft.

1 45. The 3d is very near its conjunction with the 1ft. By a figure, it wants lefs than ¼ a dia. of the 3d.

Oct. 16. 20 16. The 3d, 1¼ dia. of ♄ following the body.

21 59. It draws towards a conjunction with the 4th. The colour of the 3d is inclining to blue.

(V) 10 h. 21' 57". 103°,6.

(W) 7 h. 5' 33". 172°,5. Hence it appears that the fatellite could not be feen this night.

(X) 7 h. 1' 39". 88°,2. (Y) 8 h. 51' 33". 333°,5.

O 9.

o 9. The 3d is in conjunction with the 4th, or ¼ of the dia. of the 4th satellite past the conjunction; and one of its own dia. more north than the 4th; that is, there is a vacancy between them of one dia. of the 3d (Z).

Oct. 18. 20 18. 1 dia. of ♄ preceding the body.

21 51. 1¼ dia. of ♄ p. the body (A).

Oct. 20. 22 19. With 300, I see the 3d sat. emerging; about ¼ of its own dia. is out, at the following side of ♄.

22 44. At the distance of ¾ of its dia. following the body (B).

o 8. The f. projection passes over the 3d sat. just so as to clear it.

Oct. 28. 21 1. The 3d about 3 dia. of ♄ p. the body (C).

Oct. 30. 20 53. About 3 dia. of ♄ following the body (D).

Oct. 31. 21 13. ⅗ dia. of ♄ following the body.

21 57. There is a complete conjunction between the 3d sat. and the 2d; the following arm of the ring passes exactly between them, and points to the 6th. The distance between the 3d and 2d is about ½ the diameter of the 3d satellite, the 2d being to the north, and the 3d to the south (E).

22 o. I can see that the conjunction between the 3d and 2d satellites is past.

23 13. The 3d, ¼ dia. of ♄ following the body (F).

23 49. The 3d approaching to a contact with the body, but I can see a division yet.

23 58. A division still visible between the 3d satellite and the body of ♄.

	h.	′	″	°			h.	′	″	°
(Z)	10	17	22.	57,9.		(A)	7	51	54.	209,4.
(B)	8	36	54.	11,4.		(C)	6	22	47.	281,8.
(D)	6	6	57.	80,4.		(E)	7	6	51.	163,5.
(F)	8	22	39.	167,7.						

Nov.

Nov. 2. 21 6. The 3d satellite, 1¼ dia. of ♄ p. the body; just following the 2d, but a little more north (G).

21 44. 1¾ dia. of ♄ preceding the body.

Nov. 3. 22 1. 2¼ dia. of ♄ f. the body (H).

Nov. 4. 22 17. About 2 dia. of ♄ following the body (I).

Nov. 7. From 21 h. 28′ to 23 h. 12′ (K).

Nov. 8. 20 46. At a considerable distance following (L).

Nov. 9. 1 2. ⅓ dia. of ♄ following the body; its whole dia. is south of the arm (M).

Nov. 10. 23 30. As the calculation gives it (N).

Nov. 13. 22 33. On the following side of ♄ (O).

Nov. 15. 22 33. At some distance, preceding (P).

Nov. 16. 22 50. (Q).

Nov. 21. 1 54. The 3d, about 1½ dia. of ♄ f. the body (R).

Nov. 25. 1 21. (S).

Nov. 30. 23 47. The 3d sat. about 2½ of its own dia. following the 6th (T).

Dec. 2. 23 36. ¼ of the projection p. the body; its whole diameter is to the south of the arm.

0 22. The 3d, the 1st, and the 6th, nearly at equal distances from each other.

	h.	′	″	°		h.	′	″	°
(G)	6	8	9.	319,6.	(H)	6	59	4.	42,5.
(I)	7	11	6.	122,5.					

(K) From 6 h. 10′ 28″ to 7 h. 54′ 11″. 358°,3 to 4°,0, and consequently invisible.

	h.	′	″	°		h.	′	″	°
(L)	5	24	39.	75,5.	(M)	9	36	1.	169,1.
(N)	8	0	21.	243,5.	(O)	6	51	44.	118,8.
(P)	6	43	53.	277,8.	(Q)	6	56	55.	358,2. invisible.
(R)	8	40	57.	42,4.	(S)	8	52	10.	1,8. therefore invisible.
(T)	6	58	48.	33,9.					

D

0 50.

o 50. The 3d and 1st are in conjunction with a little space between them; the 3d being to the south, and the 1st to the north (V).

Dec. 5. 0 10. As the calculation gives it (W).

Dec. 16. 23 59. 1¼ dia. of ♄ p. the body (X).

Observations on the second satellite of Saturn.

July 18. 19 50. The 2d satellite in the line of the ring p. Saturn; but about 2 or 3° north (A).

July 23. 19 29. ¼ dia. of ♄ preceding (B).

July 27. 20 24. Upon the ff. part of the R. are two small bright points, the largest is to the south, and is nearest to the body of ♄ . (C).

20 29. The largest of the knobs is about ¼ dia. of ♄ from the body. Memorandum, I have no doubt, but that the large knob is the 2d satellite; I could nearly fee its whole diameter to the south of the ring, but not separated. Clouds came on (D).

July 28. 19 40. The 2d fat. of ♄ ¼ dia. following.

22 34. Almost a dia. f. (E).

	h.	,	ʺ	°		h.	,	ʺ	°
(V)	7	53	47.	196,3.	(W)	7	2	7.	72.4.
(X)	6	7	58.	225,5.	(A)	11	52	21.	271,6.
(B)	11	11	47.	205,8.					

(C) By calculation we find that these two bright points were the 2d and 6th satellites; but at the time of these observations I only took down phænomena as they presented themselves, leaving a solution of them to future considerations. See Note (B) to the 6th satellite.

(D) 11 h. 55′ 55ʺ. 16°,0.   (E) 13 h. 56′ 39ʺ. 158°,7.

Aug.

Aug. 18. 21 11. ¼ dia. f. R. (F).

Aug. 28. 0 14. Near 2 dia. of ♄ p. the body (G).

Aug. 29. 22 18. About 1 dia. of ♄ p. the body (H).

Aug. 31. 20 48. A few feconds nearear to ♄ than the 4th fatellite, and a little more north (I)

Sept. 8. 22 30. The 2d fat. 1¾ dia. of ♄ p. the body (K).

Sept. 10. 19 42. The 2d within 1 or 2 of its own diameters of the edge of the projection (L).

23 2. Invifible.

Sept. 11. 20 26. The 2d, 1¼ dia. of ♄ preceding the body.

22 36. 1¼, or almoft 1½ dia. of ♄ preceding the body.

1 34. 1¼ of the projection preceding R.

1 57. 1 projection p. R. (M)

Sept. 13. 22 6. There are two fatellites emerging inftead of one (N).

22 13. With 300, the neareft, 1½ of its own diameters preceding the projection. This I take to be the 2d fatellite (O).

Sept. 14. 20 27. Barely 1 projection p. R. and a little north.

21 55. The 2d, 1 dia. of the fatellite p. R. (P).

22 23. The 2d, is now vanifhed (Q). With 300, I think there is about ¼ dia. of the fatellite left.

22 30. There now, certainly, is nothing left of the 2d fat.

Sept. 16. 19 39. The 2d fat. 1¼ of the projection p. R. (R).

	h. ′ ″	°		h. ′ ″	°
(F)	11 11 27.	26,8.	(G)	13 34 42.	276,0.
(H)	11 35 5.	36,7.	(I)	9 57 29.	291,0.
(K)	11 7 48.	270,3.	(L)	8 12 24.	157,5.
(M)	14 22 27.	322,9.			

(N) See the obfervation of the 1ft fat. Sept. 13.

(O) 10 h. 31′ 13.″ 205°,0.   (P) 10 h. 9′ 21″. 334°,6.

(Q) The word vanifhed is here probably meant to denote its being gone upon the ring, to the projection of which it was approaching 28′ before.

(R) 7 h. 45′ 48″. 224°,9.

22 15.

22 15. 1 dia. of ♄ from the edge of the R. preceding, and exactly in the line of the R.

23 59. Almost 1 dia. of the R. preceding the edge of it.

1 3. About 1¼ dia. of ♄ from the preceding edge.

Sept. 17. 19 48. (S).

Sept. 18. 21 15. The 2d sat. 1¼ of the projection f. the edge; it is 1 dia. of the 1st satellite nearer to ♄ than the 1st, and a little more south.

22 35. A little less than 1 projection f. the edge.

23 14. About ¼ of the projection f. the edge.

0 12. ¼ of the projection following, and a little south.

0 27. With 300, the 2d sat. 1 of its own dia. f. the R.

0 51. With 157, the 2d sat. close to the R. so that no division can be perceived (T).

0 55. With 300, the satellite touches the R. and is a little south; its whole dia. is still out.

0 58. With 300, about ¾ of the dia. of the 2d sat. may yet be seen.

Sept. 20. 23 27. The 2d within one of its diameters following the 3d, and a little north (V).

23 51. The 2d is now more separated from the 3d.

0 45. 2 projections f. the edge of the ring.

1 22. 2½ projections f. R.

Sept. 21. 21 20. (W).

Sept. 23. 22 51. Almost 1 dia. of the R. f. the edge (X).

(S) 7 h. 50′ 55″. 356,8 invisible.   (T) 12 h. 49′ 10″. 155°,7.
(V) 11 h. 17′ 33″. 50°,6.
(W) 9 h. 6′ 58″. 170°,2 consequently invisible.
(X) 10 h. 29′ 52″. 81°,0.

Sept.

Sept. 24. 19 49. The 2d, upon the point of the ring p; but I can see no vacancy.

19 56. With 300, the same appearance nearly; but the weather is too hazy, and the planet too low to bear it well.

20 45. The 2d sat. begins now to project a little, and is a little south of the ring (Y).

20 48. I can see a division between the 2d sat. and the R.

Sept. 25. 19 34 to 22 h. 38′ (Z).

Oct. 12. 20 37. The 2d sat. one full dia. of ♄ following the body (A).

Oct. 15. 20 54. The 2d sat. 1½ dia. of ♄ f. the body (B).

23 20. About 1½ dia. of ♄ following.

Oct. 16. 20 16. The 2d sat. ¾ dia. of ♄, or a little less p. the body (C).

20 36. ¾ dia. of ♄ p. the body.

22 35. 1¼ dia. of ♄ p. the body.

0 11. 1½ dia. of ♄ p. the body.

Oct. 17. 21 30. The 2d sat. 1 projection p. the body of ♄; very hazy weather (D).

(Y) 8 h. 20′ 17″. 200°,7.

(Z) From 7 h. 5′ 33″ to 10 h. 9′ 3″, the satellite is not mentioned in my observations; though by calculation it appears, that its situation was from 325°,6 to 342°,3; and that therefore it ought to have been seen. I conclude from this that some particular cause must have rendered it invisible. Most probably it suffered an occultation from the 1st satellite, which was situated in such a manner as nearly to cover it the whole evening; in this case, the observation of the 1st belongs also to the 2d, since their diameters would certainly run together so as, perhaps, if the occultation was not always central, to form only one satellite, or rather a larger diameter than either of them.

	h.	′	″	°		h.	′	″	°
(A)	7	1	39.	42,4.	(B)	7	6	50.	77,7.
(C)	6	25	1.	205,4.	(D)	7	34	53.	343,4.

Oct.

Oct. 18. 20 18. The 2d sat. near 2 dia. of ♄ f. the body.

21 51. 1¾ dia. of ♄ f. the body.

0 52. It approaches to a conjunction with the 1st.

1 25. The 2d sat. very nearly in conjunction with the 1st.

1 38. The conjunction is complete (E). By a figure, the 2d is towards the north of the 1st; but they seem to be in contact.

Oct. 20. 21 17. The 2d sat. is emerged some time ago, and is now 1¼ of its own diameters from the body of ♄. I perceived the satellite as a protuberance before 20 h. 50′ (F).

Oct. 28. 20 58. The preceding arm, on the north side, very near to the body, contains a considerable satellite.

21 5. The 2d sat. is close to the body, on the p. side, to the north of the ring (G).

Oct. 29. 21 49. The 2d about 1⅘ dia. of ♄ f. the body (H).

Oct. 30. 20 53. About 2 dia. of ♄ p. the body (I).

Oct. 31. 21 13. The 2d, ¼ dia. of ♄ following the body.

21 57. There is a complete conjunction between the 2d and 3d. The arm passes exactly between them, and points to the 6th. The distance between the 2d and 3d is about ¼ the dia. of the 3d; the 2d satellite being to the north, and the 3d to the south (K).

22 0. I can see that the conjunction between the 2d and 3d satellites is past.

23 13. The 2d sat. is past the conjunction with the 6th.

Nov. 2. 21 6. The 2d sat. just preceding the 3d, but a little more south.

21 44. 2 dia. of ♄ p. the body, and a little more south than the 3d satellite (L).

	h.	′	″	°			h.	′	″	°
(E)	11	38	17.	137,2.		(F)	7	10	8.	15,9.
(G)	6	26	46.	344,6.		(H)	7	6	44.	119,8.
(I)	6	6	57.	245 9.		(K)	7	6	51.	22,9.
(L)	6	46	3.	284,1.						

Nov.

Nov. 3. 22 1. The 2d fat. 2 dia. of ♄ following the body (M).

Nov. 4. 23 42. The 2d fat. ¼ dia. of ♄ p. the body (N).

23 57. The dia. of the 2d fatellite is intirely fouth of the p. arm.

Nov. 7. 21 28. The 2d and 1ft fatellites, about 1 dia. of ♄, or a little farther, p. R.

21 53. The 2d fat. 1¼ dia. of ♄ p. the body (O).

Nov. 8. 20 46 to 23 h. 40′ (P).

Nov. 10. 23 30. As the calculation gives it (Q).

Nov. 13. 22 33. On the preceding fide (R).

Nov. 15. 22 33. The 2d fat. is upon the preceding arm of the ring about half-way; all its dia. is towards the fouth (S).

22 49. The 2d is not quite to the end of the R. yet, but keeps advancing.

22 56. ¾ of the projection preceding the body, or ¼ wanting to being at the end of the ring.

Nov. 26. 22 27. The 2d is upon the p. arm; its whole dia. is towards the fouth (T).

0 28. The 2d is emerged fome time paft (V).

Dec. 2. 22 50. The 2d fat. about 1¼ dia. of ♄ preceding the body (W).

Dec. 5. 0 10. As the calculation gives it (X).

	h.	′	″	°		h.	′	″	°
(M)	6	59	4.	56,9.	(N)	8	35	52.	197,3.
(O)	6	35	24.	220,9.					

(P) 5 24 39. 346,1. The firft part of the evening was not very clear, and afterwards, by the calculation, the fatellite was invifible.

	h.	′	″	°		h.	′	″	°
(Q)	8	0	21.	263,4.	(R)	6	51	44.	291,8.
(S)	6	43	53.	194,2.	(T)	5	54	43.	196,5.

(V) To emerge was here probably put for coming off the arm.

(W) 5 h. 54′ 6″. 265°,5.   (X) 7 h. 2′ 7″. 306°,3.

<div align="right">Dec.</div>

Dec. 16. 23 59. The 2d, about 1¼ or 1⅓ dia. of ♄ p. the body (Y).

Observations on the first satellite of Saturn.

July 18. 19 50. The following part of the ring of Saturn, which is a very thin lucid line, ends in a bright point like a very faint satellite (A).

I suppose the bright point on the f. part of the ring to be a very small fixed star (B).

20 14. The bright point on the following part of R. seems to have its whole dia. towards the north; and in all appearance adheres to the line.

0 48. Possibly the bright point on the nf. part of the ring may be one of the satellites, and one of the before supposed satellites may be a small fixed star (C).

(Y) 6 h. 7′ 58″. 307°,8.

(A) 11 h 52′ 21″. 146,7. This shews, that the bright point was the 1st satellite.

(B) Being the first night of my viewing the satellites this year, their places were unknown. The 6th, which was in view, I took for the 1st satellite; but, the 2d, 3d, and 4th being also before me, there remained only the supposition of some small fixed star to account for the bright point.

(C) The motion of the bright point on the ring led me to the supposition of its being a satellite; and, to make room for one, it occurred, that one of the others might be a star: for still the thought of an unknown satellite did not happen to strike me. I should have made an attempt to calculate the places of the satellites by the manuscript tables of M. de la Lande, which are now printed in the *Connoissance des Temps* for 1791; but as there chanced to be an erratum of one day's motion in the epochæ of all the satellites for 1788, of which I was not aware, I had so little satisfaction from them the year before, that I laid them by as useless, and resolved to investigate the epochæ and revolutions of the satellites from my own observations.

21 15.

21 15. The nf. bright point is advanced towards the body, so that it no longer hangs at the far end of the ring (D).

July 23. 19 29. (E).

July 27. 20 27. One dia. of ♄ f. is a small satellite (F).

July 28. 19 40. The 1st sat. 1¼ dia. of ♄ preceding the body (G).

22 34. The 1st sat. as before.

Aug. 18. 21 11. 1½ dia. of ♄ p. R. (H).

Aug. 28. 0 9. 1¼ or 1½ projection f. R. or 1 dia. of ♄ from the body (I).

Aug. 29. 22 18. About 1½ dia. of ♄ p. the body (K).

Aug. 31. 20 54. 1¼ dia. of ♄ p. the body (L).

Sept. 8. 22 51. (M).

Sept. 10. 22' 49 and 23 h. 4' (N).

Sept.

(D) 13 h. 17' 7". 158°,0. Hence we see, that the satellite had advanced 11 degrees in its orbit towards ♄, since 11 h. 52' 21" which agrees with the motion of the bright point.

(E) 11 h. 11' 47". 15,1. Therefore the 1st satellite was not visible.

(F) 11 53 55. 63,5. It was the first.

(G) 11 3 7. 247,5. The names of the satellites were by this time ascertained, and I found that the above-mentioned manuscript tables agreed pretty well with my observations this evening.

(H) 11 h. 11' 27". 294,3°.   (I) 13 h. 49' 42". 60,4°.

(K) 11 35 5. 236,0.   (L) 10 3 29. 245,4.

(M) 11 28 45. 342,9. Consequently the satellite was invisible, or at least might easily be overlooked, so near the body upon the p. arm as it must have been situated; but there was an observation made upon what is called the 1st satellite, which will be reported hereafter. See observations on the 7th satellite, Sept. 8.

(N) From 11 h. 18' 54" to 11 h. 33' 51". 3°,1 to 5°,1. The 1st satellite was invisible; but two observations were made upon what is called the first, which will be seen in the observations upon the 6th satellite. Such mistakes may easily be

E   made

Sept. 11. 1 0. The 1st fat. about 2 of its own dia. p. the projection; emerged fince I looked laft (O).

1 34. Half a projection p. R.

1 57. ¾ of the projection p. R.

Sept. 13. 22 0. There is a fatellite emerging from the preceding arm; I take it to be the 1st (P).

22 6. There are two fatellites emerging inftead of one.

22 13. The one that emerged firft, ⅓ of the projection p. R.

Sept. 14. 21 55. The 1st fat. ¼ of the projection f. R. and a very little fouth.

23 22. With 300, 1 or 1½ of its own dia. farther from the R. than the 6th, and a little more fouth (Q).

0 42. 1½ projection f. R.

1 24. 1½ projection f. R.

1 46. Much the fame as before.

Sept. 16. 19 39. The 1st fat. ½ projection f. R (R).

22 18. 1¼ projection f. the edge, and a very little fouth.

23 59. About 1 dia. of ♄ f. the edge of the R.

1 3. ¾ dia. of ♄ f. R.

Sept. 17. 19 48. The 1st almoft 1 projection p. R. (S).

20 38. 1⅓ projection p. R.

Sept. 18. 21 15. The 1st fat. 1¾ projection f. R. or one of its own dia. following the 2d fatellite (T).

22 35. 2 projections following the R.

made during the time of obfervation, as a few hours will bring one of the inner fatellites in view; but with fuch accuracy of calculating the precife moment and fituation of the fatellites, as has now been ufed, there can be no doubt to which fatellite an obfervation belongs.

	h.	′	″	°		h.	′	″	°
(O)	13	25	37.	210,7.	(P)	10	18	15.	207,4.
(Q)	11	36	6.	48,5.	(R)	7	45	52.	39,6.
(S)	7	50	55.	231,0.	(T)	9	13	45.	72,8.

0 14. 1¼ projection f. R.

Sept. 20. From 23 h. 24′ to 1 h. 28′ (V). Notwithstanding my utmost endeavour, I could not perceive the 1st satellite. From the tables I surmise that it might be under an occultation, or eclipsed by the 3d satellite; I looked for it above two hours. It could be neither in the shadow of Saturn, nor in that of the ring.

Sept. 21. 21 15. The 1st sat. 2 projections p. R. (W).

22 44. 1½ or 1¾ projection p. R.

Sept. 23. 22 51. ¾ projection p. R. and a very little north. It follows the 6th satellite 1 dia. of the 6th (X).

23 55. The 1st sat. almost touches the ring; it may want one of its diameters. Clouds interrupted the observation.

Sept. 24. 19 49. The first sat. 1¼ projection f. R. or about one of its own dia. f. the 6th.

20 45. The 1st sat. 1 full projection f. R.

22 47. Close to the following projection (Y).

Sept. 25. 19 34. The 1st sat. 1 full projection p. the edge of R. and a little north.

20 41. A little more than ¼ projection p. R.

22 38. The 1st sat. has half its dia. projecting towards the north from the ring, on the preceding side; its place on the ring is about ¼ of the projection from the body of ♄. The night is extremely clear (Z).

Oct. 12. 20 37. About ¼ dia. of ♄ p. the body.

21 24. ¼ projection of R. preceding the edge, and considerably more north.

(V) From 11 h. 14′ 33″ to 13 h. 18′ 13″. 110°,4 to 126°,6.

	h.	′	″	°		h.	′	″	°
(W)	9	1	59.	283,5.	(X)	10	29	52.	316,7.
(Y)	10	21	57.	146,4.	(Z)	10	9	3.	335,5.

E 2

22 6. The 1st almoſt touches the p. projection.

22 24. It very nearly touches the p. projection.

23 26. ¼ of the projection p. the body of ♄ ; or, as it were, faſtened upon the projection, ¼ from the end of it (A).

1 8. I ſee nothing of the 1ſt ſat.

Oct. 15. 0 52. The 1ſt ſat. ¼ projection from the body (B).

0 59. The diſtance of the 1ſt from the body is almoſt, but not quite, equal to the diſtance of the 1ſt, 3d, and 6th from each other.

1 14. The firſt is nearer to the 3d than the 3d to the 6th.

1 35. The 1ſt and 3d approach to a conjunction.

1 45. The 1ſt and 3d very near their conjunction.

Oct. 16. 0 11. The 1ſt ſatellite ¼ dia. of ♄ f. the body (C).

1 20. ¼ of the projection f. the edge of the R.; the weather remarkably clear. I can ſee the R. very diſtinctly, ſo as to judge with ſafety of the projection.

Oct. 18. 21 7. The 1ſt ſat. is lately emerged from the body of ♄ on the f. ſide.

21 12. The emerged ſat. 1 of its own dia. f. the body of ♄.

21 32. Above 2 of its own dia. following ♄.

21 51. The 1ſt ſat. ¼ dia. of ♄ f. the body.

22 36. Very nearly clear of the f. projection (D). By hiding the planet behind the field-bar very carefully, I can ſee the projection of the R. very well on the f. ſide. The preceding projection cannot be diſtinguiſhed ſo well on account of the ſatellites (E) that are upon it.

0 52. The 1ſt ſat. approaches to a conjunction with the 2d.

1 25. The 1ſt and 2d ſat. very nearly in conjunction.

	h.	′	″			h.	′	″	
(A)	9	50	11.	336,0.	(B)	11	4	11.	198,0.
(C)	10	19	22.	22,8.	(D)	8	36	47.	30,8.
(E)	The 6th and 7th.								

1 38. The conjunction is complete.

Oct. 20. 20 5. The 1st sat. ⅐ dia. of ♄ f. the body (F).

20 50. It draws towards a conjunction with the 6th sat. distance 1 dia. of the 1st. The 1st is a little towards the north.

21 26. I can just see a very small division between the 1st and the 6th.

21 51. There is a perfect conjunction between the 1st and 6th.

Oct. 28. 21 1. The 1st sat. 1 dia. of ♄ f. the body.

21 50. It draws towards a conjunction with the 6th, distance 1 full dia. of the 1st (G).

Oct. 29. 21 49. The 1st about ⅐ dia. of ♄ p. the body (H).

Oct. 30. 20 53. The 1st sat. ¼ dia. of ♄ f. the body (I).

Oct. 31. 21 13. ¼ dia. of ♄ p. the body (K).

23 13. ⅐ dia. of ♄ p. the body; its whole dia. seems to be north of the arm.

Nov. 2. 23 26. I suppose the 1st sat. to be upon the f. arm.

0 8. The f. arm contains a lucid point at the distance of ⅐ dia. of ♄ f. the body.

0 34. The 1st sat. almost ¼ dia. of ♄ f. the body (L).

Nov. 3. 22 3. The preceding arm is loaded in two places; at the far end, and about the middle.

23 48. The 1st sat. ½ dia. of ♄ p. the body (M); there seems to be another closely following it (N).

	h.	′	″	•			h.	′	″	•
(F)	5	58	20.	31,3.		(G)	7	11	39.	127,0.
(H)	7	6	44.	317,1.	—	(I)	6	6	57.	139,8.
(K)	6	22	59.	332,7.		(L)	9	35	35.	19,7.
(M)	8	45	47.	203,8.						
(N)	It was the 6th.									

o 10. I can diftinguifh the two fatellites that follow one another upon the arm; the diftance between them is ½ dia. of the fmalleft of them.

Nov. 4. 22 14. The 1ft fat. ½ dia. of ♄ f. the body (O).

22 57. The dia. of the 1ft fat. is north of the arm.

Nov. 7. 21 28. The 1ft and 2d about 1 dia. of ♄, or a little more, p. the body (P).

21 53. The 1ft fatellite 1¼ dia. of ♄ p. the body.

Nov. 8. 20 46. ⅞ dia. of ♄ f. the body (Q).

Nov. 10. 23 30. The 1ft as the calculation gives it (R).

Nov. 13. 22 33. On the preceding fide (S).

Nov. 15. 22 33. About ¼ dia. of ♄ p. the body (T).

Nov. 16. 22 50. Upon the end of the f. arm (V).

Nov. 21. 0 54. ¾ dia. of ♄ f. the body (W).

Dec. 2. 22 49. The 1ft fat. about 1 of its own dia. p. the 6th.

23 38. It is paft the conjunction with the 6th, which it now follows, and it is a little more north than the 6th.

o 22. The 1ft is equally diftant from the following 6th, and the preceding 3d (X).

o 50. The 1ft and 3d are in conjunction, with a little fpace between them, the 1ft being to the north.

Dec. 5. 0 8. (Y).

(O) 7 h. 8' 6". 21°,5.

(P) 6 h. 10' 28". 226°,0. By the equal diftance which is mentioned, it appears, that the 1ft and 2d fatellites were in conjunction; and this agrees alfo with the next obfervation, compared with that of the 2d fat. Nov. 7th.

	h.	′	″	°		h.	′	″	°
(Q)	5	24	39.	50,8.	(R)	8	0	21.	92,7.
(S)	6	51	44.	295,9.	(T)	6	43	53.	316,2.
(V)	6	56	55.	148,6.	(W)	8	40	57.	35,9.
(X)	7	25	51.	323,5.	(Y)	7	0	7.	172,1 invifible.

Dec.

Dec. 16. 23 59. The 1ft fat. *a* little more than 1 dia. of ♄ f. the body (Z).

Dec. 24. 0 5. (A).

Dec. 25. 1 36. The 1ft fat. is upon the end of the f. arm (B).

Obfervations on the fixth fatellite of Saturn.

July 18. 19 50. The *firft fatellite* of ♄ exactly in a line of the R. preceding (A).

July 27. 20 24. Upon the ff. part of the ring are two fmall bright points; the largeft, to the fouth, is neareft to the body (B), and the fmalleft, to the north, is at the farther end (C).

Aug. 28. 23 26. With the 40-feet reflector, I fee the five known fatellites of Saturn, and alfo another exactly in a line with the ring, interpofed between the 2d fatellite and the ring on the preceding fide, while the 1ft, 3d, 4th, and 5th are on the following one. It has fo much the appearance of the other fatellites, and ranges fo well with them, that I have not a moment's doubt but that it is a fixth fatellite. It is lefs bright

	h.					h.			
(Z)	6	7	58.	102,4.		(A)	5	42 33.	184,3 invifible.
(B)	7	9	23.	26,3.					

(A) By computation for 11 h. 52′ 21″ we find, that the 6th fat. was 302,4; which is exactly in the place where a fatellite called the firft was obferved; but it appears alfo from the calculation which has been given in the note A of the 1ft fatellite, that this obfervation cannot belong to the real 1ft; the 6th fatellite therefore was feen this evening without being known; and this explains all the difficulties which occurred with regard to the real 1ft fatellite. See obfervations on the 1ft fatellite, July 18.

(B) It was the 2d fatellite. See obfervation on the 2d fatellite, July 27.

(C) 11 h. 50′ 56″. 147°,1, which agrees exactly with the place of the 6th fatellite.

than

than the rest, but seems to have light enough to be seen by my 20-feet telescope.

o 9. 20-feet reflector. The new satellite ⅓ of the projection of the ring preceding the edge of the R. (D).

o 20. A very small star about 60° ff. ♄, and 1¼ dia. of ♄ distant from the body (E).

1 16. The small star is gradually left behind so as now to make an angle of about 35° ff. ♄; while at the same time the planet has carried along with him the new satellite.

1 24. The 6th satellite ½ of the projection of the R. p. the ring.

1 46. The same small star is now only about 25° ff. ♄.

1 49. The new satellite is now not much more than ¼ the projection from the ring.

2 2. Saturn is gone on, <u>in a retrograde order</u> with respect to the small star, and has carried along with him the new discovered satellite.

Sept. 8. 22 30. The new or 6th sat. ⅓ of the projection of the R. directly preceding (F).

Sept. 10. 22 49. The *first satellite* less than the projection from the following arm; extremely faint (G).

23 4. The *first satellite* the length of the projection following the arm; it is so faint that I cannot expect to see the new satellite (H).

Sept.

(D) 13h. 29′ 42″. 294°,2.

(E) This star was immediately taken notice of, to verify the discovery of the 6th satellite.

(F) 11 h. 7′ 48″. 279°,2.

(G) 11 h. 18′ 54″. 86°,8. Which agrees perfectly with the 6th satellite, though it is here by mistake called the 1st.

(H) As I mistook the 6th satellite for the 1st, it was natural enough to find it
very

Sept. 14. 21 59. I think I perceive a satellite between the 1ft and the following projection close to the ring. 300 leaves it doubtful (I).

22 23. The 6th fat. ¼ of the projection f. R.; fo close to the 1ft that it requires great attention to be diftinguifhed. With 300, the 6th is 1 or 1½ dia. of the 1ft fat. nearer the R. than the 1ft, and a little more north than the 1ft, that is to fay, very exactly in the line of the ring.

23 45. With 460, the 6th fat. is very near one whole projection f. R.

0 42. The 6th fat. 1 full projection f. R. (K).

1 24. The new fat. 1 projection f. R.

1 46. Very nearly, but not quite, 1 projection f. R.

Sept. 16. 22 18. The *third satellite* ¼ the projection from the preceding edge of R.

22 25. The *third satellite* is extremely fmall, and hardly to be feen; but I have no doubt.

23 59. *The third satellite* a little more than ¼ the projection preceding the edge.

0 16. *The third* much lefs than the 1ft and 2d, partly owing to its proximity to the planet; but probably there may be an apparent change of magnitude from a revolution upon its axis.

1 3. *The third* about ¼ of the projection p. R. (L).

Sept.

very faint, and of courfe to fuppofe that the night was not clear enough to fee the 6th, while at the fame time I was making an obfervation on that very fatellite. But it muft here be remembered, that the time of its revolution was not yet well afcertained.

(I) The calculation for 10 h. 13′ 20″ gives 46°.0, which fhews that the fatellite was there.

(K) 12 h. 55′ 53″. 75°,7.

(L) The 6th fat. was this evening miftaken for the 3d; but the calculation for

Sept. 17. 19 52. The 6th sat. 1 projection, or rather more f. the projection; extremely faint.

20 38. 1 full projection following (M).

22 55. ½ projection f. and a little south; extremely small.

23 49. ⅓ projection f. and a little south.

0 58. ⅓ projection following.

1 46. Near ¾ of the projection following (N).

Sept. 21. 21 10. The 6th sat. 1 full projection f. R.; much fainter than the 1st; hazy weather.

21 20. 1 full projection f. the edge, and exactly in the line of the ring. I see it very well; it is less than the 1st.

22 9. 1¼ of the projection f. the edge (O).

22 39. Nearly 1¼ projection f. the edge of the R. exactly in the line of the R.

Sept. 23. 22 51. The 6th sat. 1 projection p. the edge; or 1 of its own diameters p. the 1st (P).

Sept. 24. 19 46. I suspect the new or 6th satellite to be 1 projection f. the edge (Q).

19 49. The 6th is very near 1 projection f. the edge; it precedes the 1st sat. about 1 dia. of the 1st.

20 45. The 6th a little more than ½ projection f. the edge.

13 h. 8′ 59″, which gives 243°,7, shews that these observations belong to the 6th; and therefore explains all the difficulty about the supposed change of magnitude of the 3d.

(M) 8 h. 40′ 47″. 97°,6.

(N) The estimation ¾ is probably a mistake in writing down, and should have been ¼; perhaps also some change in the atmosphere, or other circumstance, may have induced an error of estimation, which, in such minute objects, will now and then take place.

(O) 9 h. 55′ 50″. 82°,5.   (P) 10 h. 29′ 52″. 254°,3.

(Q) 7 h. 21′ 28″. 122°,6.

                                                              Sept.

Sept. 25. 22 36. The 6th almost ¾ projection f. the edge of the R.

23 42. The 6th sat. very nearly 1 projection f. R. (R).

23 52. The 6th sat. is much larger than the 7th.

Oct. 12. From 22 h. 6′ to 1 h. 8′ (S).

0 58. *The seventh sat.* extremely small upon the point of the preceding projection, and a little towards the south.

1 20. The distance of *the seventh* increases. The satellite seems to be clear of the projection; but I can see no division yet; its whole dia. seems to be to the south; I see it full as well as I saw the 6th, or rather better (T).

1 35. *The seventh* is clear of the projection.

Oct. 15. 20 47. The 6th sat. 1 dia. of ♄ p. the body.

21 34. The 6th about ¾ of the projection p. the edge of R. or very near 1 dia. of ♄ p. the body; just ff. the 3d; it is in the line of the R. (V).

22 25. The 6th sat. will be in conjunction with the 3d in a very short time, the 3d being still a little p.

22 39. The conjunction is so complete now, that I have lost the 6th. The 3d, however, appears to be a little lengthened out towards the south. Distance of the conjoined satellites

(R) 11 h. 12′ 52″. 67°,7.

(S) There were five observations made upon the 6th satellite, but they belong to the 7th. There were also three observations made upon the 7th which belong to the 6th, and are here given; we are to observe, that the revolution of the 7th was not yet ascertained, and that, consequently, a mistake of one new satellite for another could easily be made.

(T) 11 h. 43′ 53″. 220°,9. The calculation of its place shews plainly that it was the 6th; and the remark in this observation of its being brighter than the other satellite perfectly agrees with the calculation.

(V) 7 h. 46′ 43″. 246°,0.

F 2   barely

barely 1 dia. of ♄ from the body; or juſt 1 dia. of ♄, in-cluding the dia. of the 3d ſat.

23 59. The 6th near 2 diameters of the 3d ſatellite paſt the conjunction.

0 59. The 6th, the 3d, and the firſt ſatellites are at equal diſtances from each other.

1 3. The 6th is one dia. of ♄ from the body.

1 39. The 6th nearly 1 dia. of ♄ p. the body.

Oct. 16. 20 16. The 6th ſat. ⅔ dia. of ♄ f. the body; too low to be very accurate.

20 36. The 6th one full projection f. the body; extremely faint.

20 50. The 6th one projection f. the body.

21 11. The 6th ¾ of a projection f. the body.

21 55. The 6th ½ projection f. the body, or a little leſs (W).

22 5. The 6th advances towards a contact with the f. part of the body; I can, however, ſtill look between them.

22 18. I can ſtill ſee between the planet and the 6th ſat.

22 22. The 6th leſs than its own dia. from the planet.

22 25. It is in contact with the body of ♄.

22 41. I can ſtill perceive the 6th ſat.

22 44. The 6th is not quite vaniſhed.

22 47. The ſatellite is no longer viſible.

Oct. 17. 21 30. The 6th ſat. ¼ projection f. the body, very hazy weather (X).

Oct. 18. 20 40. The 6th ſat. is emerging from behind the 3d.

20 46. The 6th ſat. which emerged from behind the 3d is a little north of the line of the ring, and of the 3d.

(W) 8 h. 3′ 44″. 151°,9.   (X) 7 h. 34′ 53″ 49°,4.

21 36.

21 36. The 6th is going towards ♄, and is about ¼ dia. of ♄ preceding the body.

22 51. ¼ dia. of ♄ p. the body.

22 26. The 6th about ⅕ dia. of ♄ p. the body.

22 40. The 6th ¼ dia. of ♄ p. the body.

23 17. The 6th approaches to a conjunction with the 7th.

23 37. The conjunction of the 6th and 7th satellites is past. The satellites are, however, too near the planet to see exactly how they are placed.

0 12. The 6th a little more than 1 of its own dia. p. the body of ♄ (Y).

Oct. 20. 20 5. The 6th sat. 1¼ dia. of ♄ f. the body. (Z).

20 50. The 6th and 1st satellites are drawing towards a conjunction; distance between them 1 dia. of the 1st sat.

21 26. I can just see a very small division between the 6th and the 1st.

21 51. There is a perfect conjunction between the 6th and the 1st.

22 22. The 6th sat. appears again.

22 43. The 6th is in the middle, between the 1st and 2d satellites.

23 50. I perceive the 6th sat. near the 3d towards the 2d; and on the south of the line that joins the 3d and 2d; but nearer the 3d than the 2d.

Oct. 28. 20 58. The 6th sat. about ¼ projection f. the edge of the R.

21 5. The 6th about ¼ dia. of ♄ f. the body (A).

Oct. 29. 21 49. The 6th just f. the 1st (B).

	h.	′	″	°		h.	′	″	°
(Y)	10	12	31.	341,0.	(Z)	5	58	20.	100,0.
(A)	6	26	46.	47,5.					
(B)	7	6	44.	317,5.	For the place of the 1st, see the 1st sat. Oct. 29.				

Oct.

Oct. 30. 20 55. I suspect the 6th on the edge of the p. arm; but moon-light is too strong.

23 44. The 6th sat. ¾ projection p. the edge of the R.

23 55. The 6th sat. ⅞ dia. of ♄ p. the body.

0 42. The 6th sat. 1¼ dia. of ♄ p. the body (C).

Oct. 31. 21 13. The 6th sat. ⅞ dia. of ♄ p. the body.

21 57. The f. arm of the R. passes between the 3d and 2d satellites, and points to the sixth.

23 57. The 6th full ½ dia. of ♄ following the body (D).

Nov. 2. 21 44. The 6th sat. 1¼ dia. of ♄ p. the body, and a little north; extremely faint (E).

22 17. The 6th sat. 1 full dia. or 1¹⁄₈ dia. of ♄ p. and a very little north.

22 53. The 6th seems to be still 1¹⁄₁₆ dia. of ♄, or rather more, p. the body, but the weather is hazy and foggy.

23 15. The 6th sat. 1 dia. of ♄ p. the body.

23 27. The 6th sat. ÷ of the projection p. the edge or very near 1 dia. of ♄ p. the body.

0 15. The 6th sat. ⁷⁄₄ dia. of ♄ p. the body.

0 58. The 6th sat. is still clear of the p. arm.

1 16. The 6th sat. ÷ dia. of ♄ p. the body; a very little p. the edge of the ring, and a little north.

Nov. 3. 22 3. The p. arm is loaded in two places, at the far end and about the middle (F.)

23 54. There seems to be a satellite closely following the 1st (G).

	h.	′	″	°		h.	′	″	°
(C)	9	55	20.	250,9.	(D)	9	6	32.	144,9.
(E)	6	46	3.	284,7.					

(F) They were the 1st and 6th satellites. See 1st sat. Nov. 3.

(G) 8 h. 51′ 46″. 210°,5.

                                                     0 10.

0 10. The distance between the two satellites upon the arm is half the dia. of the smallest.

Nov. 4. 22 17. The 6th satellite $\frac{2}{7}$ dia. of ♄ f. the body (H).

23 48. The 6th about $\frac{1}{4}$ or $\frac{2}{7}$ dia. of ♄ following the body.

Nov. 7. 21 28. The 6th towards the end upon the f. arm (I).

22 39. The 6th is drawn a little nearer towards ♄.

Nov. 8. 20 46. The 6th about $\frac{1}{2}$ dia. of ♄ f. hazy weather, I do not see it well enough to estimate its distance very exactly.

21 16. The 6th sat. $\frac{5}{7}$ dia. of ♄ f. the body.

22 2. The 6th sat. $\frac{7}{8}$ dia. of ♄ f. the body.

23 40. The 6th sat. $1\frac{1}{8}$ dia. of ♄ f. the body (K).

Nov. 9. 21 42. The 6th sat. $\frac{5}{8}$ dia. of ♄ p. the body, and a little north (L).

Nov. 10. 21 33. The p. arm, near the end, seems to contain a sat. probably the 6th.

21 39. The 6th full $\frac{1}{2}$ dia. of ♄ p. the body; almost intirely to the south of the arm (M).

22 28. The 6th is clear of the p. arm, and is about $\frac{3}{4}$ dia. of ♄ p. the body.

23 27. The 6th almost $\frac{7}{8}$ dia. of ♄ p. the body.

0 10. The 6th sat. 1 full dia. of ♄ p. the body.

Nov. 13. 22 33. The 6th sat. on the p. side (N).

Nov. 15. 22 33. The 6th sat. about 1 dia. of ♄ f. the body (O).

Nov. 19. 21 55. The 6th sat. $\frac{2}{3}$ dia. of ♄ f. the body (P).

	h.	′	″	°			h.	′	″	°
(H)	7	11	6.	94,8.		(I)	6	10	28.	151,9.
(K)	8	18	11.	78,0.		(L)	6	16	34.	318,7.
(M)	6	9	39.	220,1.		(N)	6	51	44.	296,0.
(O)	6	43	53.	100,0.		(P)	5	50	17.	61,1.

Nov.

Nov. 21. 0 54. The 6th at a little dist. p. the edge of the ring (Q); cloudy weather.

Nov. 25. 1 21. The 6th about ¼ dia. of ♄ following the body (R).

1 27. The 6th about ½ the projection preceding the edge of the projection.

Nov. 26. 22 22. The 6th near 1 dia. of ♄ f. the body (S).

0 30. Very nearly in conjunction with the 4th.

Nov. 30. 23 47. The 6th full ¼ dia. of ♄ f. the body; about 2½ dia. of the 3d sat. p. the 3d (T).

Dec. 2. 22 49. The 6th about ⅜ dia. of ♄ p. the body; about ½ dia. of the 1st f. the 1st.

23 38. The 6th sat. is past its conjunction with the 1st, which it now precedes.

0 22. The 6th, the 1st, and 3d satellites, are nearly at equal distances from each other.

0 52. The 6th sat. nearly 1 dia. of ♄ p. the body (V).

Dec. 5. 0 8. The 6th sat. ½ projection p. the arm (W).

Dec. 15. 0 35. The 6th about ¼ dia. of ♄ f. the body, and a little north (X).

Dec. 16. 23 59. The 6th full ¼ dia. of ♄ p. the body (Y).

Dec. 24. 0 5. The 6th sat. 1¼ dia. of ♄ p. the body; or 1½ projection p. the edge of R. (Z).

	h.	′	″	°		h.	′	″	°
(Q)	8	40	57.	257,8.	(R)	8	52	10.	230,7.
(S)	5	49	44.	100,1.	(T)	6	58	48.	83,6.
(V)	7	55	46.	259,4.	(W)	7	0	7.	317,3.
(X)	6	47	48.	62,0.	(Y)	6	7	58.	317,3.
(Z)	5	42	33.	254,2					

Observations

Observations on the seventh satellite of Saturn.

Sept. 8. 22 51. The *first satellite* ⅓ the dia. or a little lefs of the projection ff. R. (A).

Sept. 14. 1 29. A fuppofed 7th fat. exceffively faint, ⅓ projection p. R. exactly in the line of the R. fainter than the laft new one.

1 46. The fuppofed 7th half a projection p. the R. (B).

Sept. 17. 21 0. A fecond new fatellite exceffively faint, ⅓ projection p. the edge of the R. (C).

22 55. The new, or 7th fat. ⅓ projection p. R. fo exceffively fmall that, if I had not feen it before, it would have been impoffible to perceive it now.

(A) Not being acquainted with more than fix fatellites, and having the 2d, 3d, 4th, 5th, and 6th in view, it was natural enough to call the remaining one, on which this obfervation is made, the 1ft; but from the note M of the 1ft fat. it appears, that it could not be in the place where this was feen; and by calculating from the tables of the 7th fat. we have its place for 11 h. 28′ 45″. 106°,0, which agrees exactly with the fituation pointed out. From a figure, it appears, that the fat. was extremely fmall, and lefs than half its diameter fouth of the line of the R.

(B) I was now on the look-out for very fmall ftars that were in any fituation likely to be fatellites of ♄, and always noticed them: for inftance, " Sept. 11. " 20 h. 42′. A fuppofed 7th fat. exactly in the line of the R. or a very little " fouth, exceffively faint, only to be feen when I hide ♄ by the field bar. Sept. " 14. 20 h. 40′. The 7th of Sept. 11. is left in its place." So here this fuppofed 7th is marked down, and Sept. 16. 20 h. 13′ I find it is faid, that " the " fuppofed 7th of the 14th is a fmall fixed ftar, left in the place where it was that " evening; but as the configuration of ftars which pointed out this fuppofed 7th was very coarfe, and hardly fufficient to determine the place, and as by calculation it appears, that the 7th fatellite was in the fituation where this obfervation places it, at 13 h. 59′ 43″, viz. 278°,2, it is probable enough, that I faw the real fatellite this evening.   (C) 9 h. 2′ 43″. 265°,6.

G   23

23 1. After a more attentive observation and hiding the planet, I see the 7th sat. is not less than ½ projection p. R.

23 31. Forty-feet reflector. I see six satellites at once, and being perfectly assured that the 2d is invisible, it becomes evident that Saturn has seven satellites. This new sat. is excessively small.

Sept. 18. 22 4. The new sat. near ½ projection p. R. and a little south, but so faint that I hardly perceive it (D).

22 36. I cannot perceive the new satellite with the utmost attention (E). Indeed it was so faint before, that I almost entertained a doubt of its reality.

Sept. 25. 23 48. The 7th sat. I believe is between the 6th and the R. or ⅓ projection f. the edge (F).

23 52. I see it very plainly; it is much smaller than the 6th; I have many times this evening before suspected it, but the weather has been too hazy.

Oct. 12. 22 6. *The sixth sat.* (G) close to the f. projection, and a little north.

22 13. I see *the sixth sat.* very well; but the projection is too faint to estimate the distance by it with any accuracy.

22 24. *The sixth* being nearer to Saturn on the f. side than the 1st on the preceding, must be quite close to the f. projection, or touching it.

(D) 10 h. 2′ 37″.   303°5.

(E) From the calculated place 10 h. 34′ 32″.   312°,0, we see, that the satellite was drawn upon the arm, and therefore might easily be overlooked, especially as its revolution was unknown.

(F) 11 h. 18′ 48″.   117°,9.

(G) The satellite is here called the 6th, and we have seen before, in the note (S) of the 6th sat. that the 6th was called the 7th; but the tables of these satellites leave no doubt to which of them the observations belong.

Oct.

Oct. 12. 23 35. *The fixth fat.* 1 projection, or perhaps a little lefs, f. the body; I fee it with great difficulty, but have no doubt (H).

1 8. I fee nothing of *the fixth* (I).

Oct. 16. 20 23. The 7th fat. ½ projection f. the body; that is, the fat. is upon the middle of the arm (K).

20 36. The 7th a little more than ¼ projection f. the body; extremely faint.

20 50. The 7th fat. 1 of its own dia. f. the body of ♄.

21 11. The 7th is very nearly in contact with the body.

21 15. I can ftill perceive the 7th fat. by means of the field bar hiding the planet.

21 55. The 7th is gone.

1 29. I have a ftrong fufpicion of a fat. upon the p. projection not far from the end of it (L).

Oct. 18. 21 25. I am pretty fure the fat. is about 1 of its own dia. p. ♄ (M).

21 26. Very clear. I fee the 7th fat. very plainly.

21 35. About 2 of its own dia. from the body of ♄, and a little north of the R.

21 43. The 7th fat. ¼ projection p. the body.

21 51. The 7th fat. ¼ dia. of ♄ p. the body.

22 26. The 7th fat. ¼ dia. of ♄ p. the body.

(H) The calculated place 9h. 59′ 10″. 111°,2, gives the fatellite farther from the arm than the obfervation; but as this alfo mentions the fat. was feen with difficulty, the interval might appear lefs than it would have done in a very clear view of the fat.

(I) The leaft change in the atmofphere would make the fat. invifible; and by the tables it alfo was now very nearly going upon the ring.

	h.	′	″	°		h.	′	″	°
(K)	6	31	59.	144,4.	(L)	11	37	9.	225,3.
(M)	7	25	58.	202,7.					

22 40.

22 40. The 7th seems still to be where it was.

23 17. The 7th approaches to a conjunction with the 6th.

23 37. The conjunction of the 7th and 6th satellites is past. They are too near the planet to see exactly how they are placed.

o 20. The 7th sat. $\frac{1}{5}$, or near $\frac{1}{4}$, dia. of ♄ p. the body.

o 24. The 7th is clear of the projection.

o 36. The 7th near $\frac{1}{4}$ projection p. the edge of the ring. I see the R. well enough to estimate by it.

o 59. The 7th sat. $\frac{1}{4}$, or nearly $\frac{2}{7}$, dia. of ♄ p. the body.

1 21. The 7th sat. $\frac{2}{7}$ dia. of ♄ p. the body (N).

Oct. 20. 21 26. I have a glimmering sight of the 7th sat.

21 56. The 7th is perfectly detached from the p. arm.

23 5. The sat. $\frac{1}{4}$ of the dia. of ♄ p. the body, or thereabout.

23 37. The 7th extremely faint, near 1 dia. of ♄ p. the body; but the estimation of the distance is not very exactly to be had, as I am obliged to hide the planet when I see the sat. There is a high wind, and the air being dry, the telescope does not act so well as it did 1½ hour ago.

o 8. The 7th sat. $\frac{1}{4}$ dia. of ♄ p. the body; or $\frac{1}{3}$ (or nearly $\frac{1}{4}$) projection p. R. I see the ring very plainly (O).

o 20. The 7th sat. about $\frac{2}{7}$ dia. of ♄ p. the body.

1 20. The 7th sat. about $\frac{2}{7}$ dia. of ♄ p. the body.

Nov. 4. 22 23. The p. arm seems to be loaded about $\frac{2}{7}$ dia. of ♄ from the body (P).

Nov. 7. 22 0. The 7th sat. $\frac{2}{7}$ dia. of ♄ p. the body, excessively small; but I see it extremely well, and can keep it in view; it is just following the 1st and 2d sat.

	h.	′	″	°		h.	′	″	°
(N)	11	21	20.	265,1.	(O)	10	0	40.	287,9.
(P)	7	17	5.	214,3.					

22 9.

22 9. I fee the 7th extremely well, notwithſtanding its ſmallneſs.

22 39. The 7th about $\frac{7}{8}$ dia. of ♄ p. the body (Q).

23 12. The 7th nearly the ſame as at 22 h. 39′, or perhaps a little nearer to ♄.

Nov. 8. 21 17. The 7th is clear of the p. arm; but I do not ſee it well enough yet to eſtimate how much.

22 0. The 7th ſat. $\frac{1}{4}$ dia. of ♄ p. the body (R).

23 31. The 7th is upon the p. arm I ſuppoſe, for the weather is now very clear, and I ſee it no longer. There is a ſmall protuberant point on the arm, which I take to be the ſatellite; but, as it has been cloudy, I have not been able to follow it ſo as to ſee it go on ſince 22 h. 2′.

23 40. I ſee the 7th upon the arm.

Nov. 10. 21 39. The p. arm is a little gouty, not quite $\frac{1}{4}$ dia. of ♄ preceding the body (S).

Nov. 15. 22 27. The 7th ſat. is clear of the f. projection (T).

22 39. The 7th ſat. between the 6th and the projection of the R. and a very little to the north.

22 44. The 7th conſiderably leſs than the 6th; I ſee it however very well, notwithſtanding the difficulty of its ſituation.

22 56. By a figure, at a conſiderable diſtance following.

Nov. 16. 22 50. The 7th leſs than 1 dia. of the 1ſt following the firſt, and a little north (V).

Nov. 29. 0 38. A ſmall luminous point on the f. arm (W).

	h.	′	″	°		h.	′	″	°
(Q)	7	21	16.	281,4.	(R)	6	38	27.	291,9.
(S)	6	9	39.	328,5.	(T)	6	37	54.	85,7.
(V)	6	56	55.	112,8.	(W)	7	53	35.	53,3.

Dec.

Dec. 2. 23 38. I fufpeƈt the 7th to be juſt detached from the f. arm (X).

 o 24. I cannot fee the 7th, though I tried often for it.

 o 56. The 7th fat. is not vifible.

From the obfervations on the feven fatellites of Saturn that have been here delivered, and clofely compared with their calcu-lated places, it appears evidently that the revolutions of thefe fatellites are fo well afcertained, that we may, without hefitation, determine that no phænomenon on the ring of Saturn, in the fhape of lucid fpot, protuberant point, or latent fatellite, can be occafioned by any of them, when, upon computation, we find that the place of the fatellite differs from that where fuch appearances were obferved. In confequence of this deduƈtion, I found, that the obfervations, which will be given prefently, could not be explained by any of the known fatellites; it remained, therefore, to be examined to what caufe to afcribe the appearance of fuch lucid fpots.

The firft idea that occurred was that of another fatellite, ftill clofer to the ring than the feventh; and if a revolution, flower than about 15 hours and a quarter, could have been found, which would have taken in the moft material places in which bright fpots were feen, I fhould have continued of opinion that an eighth fatellite, exterior to the ring, did exift, notwith-ftanding more obfervations had been wanting to put the matter out of all doubt. But this being impraƈticable, I examined, in the next place, what would be the refult if thefe fuppofed fatellites, or protuberant points, were attached to the plane or edge of the ring.

<div align="center">(X) 6 h. 41′ 59″. 100°,0.</div>

<div align="right">As</div>

As obfervations, carefully made, fhould always take the lead of theories, I fhall not be concerned if fuch lucid fpots as I am now going to admit, fhould feem to contradict what has been faid in my laft Paper, concerning the idea of inequalities, or protuberant points. We may however remark, that a lucid, and apparently protuberant point, may exift without any great inequality in the ring. A vivid light, for inftance, will feem to project greatly beyond the limits of the body upon which it is placed. If therefore the luminous places on the ring fhould be fuch as proceed from very bright reflecting regions, or, which is more probable, owe their exiftence to the more fluctuating caufes, of inherent fires acting with great violence, we need not imagine the ring of Saturn to be very uneven or diftorted, in order to prefent us with fuch appearances as will be related. In this fenfe of the word, then, we may ftill oppofe the idea of protuberant points, fuch as would denote immenfe mountains of elevated furface.

On comparing together feveral obfervations, a few trials fhew that the brighteft and beft obferved fpot agrees to a revolution of 10 h. 32' 15",4; and, calculating its diftance from the center of Saturn on a fuppofition of its being a fatellite, we find it 17",227, which brings it upon the ring. It is therefore certain, that unlefs we fhould imagine the ring to be fufficiently fluid to permit a fatellite to revolve in it, or fuppofe a notch, groove, or divifion in the ring, to fuffer the fatellite to pafs along, we ought to admit a revolution of the ring itfelf.

The denfity of the ring indeed may be fuppofed to be very inconfiderable by thofe who imagine its light to be rather the effect of fome fhining fluid, like an aurora borealis, than a reflection from fome permanent fubftance; but its difapparition in general, and in my telefcopes its faintnefs when turned edge-

ways,

ways, are in no manner favourable to this idea. When we add also, that this ring cafts a deep fhadow upon the planet, is very fharply defined both in its outer and inner edge, and in brightnefs exceeds the planet itfelf, it feems to be almoft proved, that its confiftence cannot be lefs than that of the body of Saturn; and that. confequently, no degree of fluidity can be admitted fufficient to permit a revolving body to keep in motion for any confiderable time.

A groove might afford a paffage, efpecially as on a former occafion we have already confidered the idea of a divided ring. A circumftance alfo which feems rather to favour this idea is, that, in fome obfervations, a bright fpot has been feen to pro- ject equally on both fides, as the fatellites have been obferved to do when they paffed behind the ring. But, on the other hand, we ought to confider that the fpot has often been obferved very near the end of the arms of Saturn's ring, and that the cal- culated diftance is confequently a little too fmall for fuch ap- pearances, and ought to be 19 or 20 feconds at leaft. We fhould alfo attend to the fize of the fpot, which feems to be variable; for it is hardly to be imagined that a fatellite, brighter than the fixth, and which could be feen with the moon nearly at the full, fhould fo often efcape our notice in its frequent revolutions, unlefs it varied much in its apparent brightnefs.

To this we muft add another argument drawn from the number of lucid fpots, which will not agree with the motion of one fatellite only; whereas, by admitting a revolution of the ring itfelf, in 10 h. 32′ 15″,4; and fuppofing all the fpots to adhere to the ring, and to fhare in the fame periodical return, provided they laft long enough to be feen many times,

we

we shall be able to give an easy solution to all the remaining observations.

For instance, let α, β, γ, δ, ϵ, represent five spots on the ring of Saturn, situated as in fig. 2.; where the ring is supposed to be divided into 360 degrees, and the spot α placed at 271°,5; β at 70°,2; γ at 183°,0; δ at 142°,5; and ϵ at 358°,6. Then will the ring, with the spots thus placed, serve as an epocha for the year 1789; by which, with the assistance of a table constructed upon the before-mentioned period of the rotation of the ring, we may calculate their situation for any required time; and to render this calculation perfectly convenient, I have given a table, ready prepared for the purpose, at the end of the other tables.

The following observations have all been previously calculated by the tables of such of the seven satellites as were not already in view, and have been found to belong to neither of them; but in the notes that are given with them they have been again calculated by the table of the rotation of the ring for every time they were observed, on a supposition of their being spots adhering to it.

Observations not accounted for by satellites.

July 28. 22 31. I now perceive between the nearest sat. and $\hbar$, on the s. side, a small lucid point, like an emerging satellite (A).

22 37.

(A) My surmise of its being an emerging satellite so early as the beginning of the season, when I was still unacquainted with the minute phænomena that offered themselves afterwards, shews plainly, that the lucid point was of a sufficient brightness to deserve notice. The five old satellites were in view, and the

H   6th

22 37. The laſt diſcovered point, not quite half-way be-tween the 3d ſat. and the body of Saturn; may be it is a 6th ſat. By a figure, the greateſt part of its diameter is to the north of the ring (B).

Aug. 29. 23 1. The preceding projection contains a ſmall inequality. By a figure, it follows the 3d ſat. about ⅓ of the projection of the ring (C).

Sept. 16. 19 39. I ſuſpect one of the ſatellites cloſe to the ring following (D).

20 6. I am pretty ſure there is a ſatellite cloſe to the following arm, and a very little to the north. 300 leaves it doubtful (E).

Oct. 15. 20 58. I ſuſpect a ſatellite upon the preceding pro-jection, not far from the end of it (F).

21 39. I cannot perceive the ſatellite on the preceding arm ſuſpected at 20 h. 58′ (G).

6th and 7th by calculation could not occaſion this appearance, the former being at 72°,3; the latter on the oppoſite ſide at 299°,4. Suppoſing this, therefore, to be the ſpot I have called α, its place for 13 h. 53′ 39″ would be 36°,8; which might make it appear like an emerging ſatellite.

(B) By this time the ſpot was at 40°,3, which agrees with the obſerved ſitua-tion. As the greateſt part of its diameter appeared to be north, we may ſurmiſe, that the ſpot, which muſt have been of a very conſiderable ſize and brightneſs, was ſituated on the northern plane of the ring, and within a ſecond or two from the outward edge of it. The ring itſelf was now ſo near having its edge directed towards us, that it required no great elevation of the ſpot to render it viſible, notwithſtanding it was then in the fartheſt part of its circuit.

(C) The ſpot α, at 12 h. 17′ 58″ was 301°,5.

(D) The ſpot β, at 7 h. 45′ 52″ was 58°,1. This ſpot was probably alſo on the northern plane, and on the very edge, but not ſo conſiderable as α.

(E) It was now advanced to 73°,4.

(F) The ſpot γ, at 7 h. 10′ 49″ was 305°,0. Its ſituation on the ring was probably on the ſouthern plane, and at ſome conſiderable diſtance from the outward edge.

(G) It was now advanced to 328°,3; and therefore could hardly be ſeen any longer.

Oct.

Oct. 16. 1 29. I was not without a suspicion of another satellite upon the preceding arm, not quite so far advanced as the former (H).

Oct. 18. 20 22. I suspect two satellites upon the p. arm (I).

20 42. I make no doubt but that there is at least one sat. upon the p. arm (K).

21 14. I am in doubt whether it be a sat. upon the p. arm, or the arm itself (L).

21 17. Unless the p. arm be much brighter than the f. one, it must contain a satellite (M).

1 1. I am pretty sure the end of the preceding projection is loaded with two satellites. By a figure, one is placed $\frac{1}{4}$ projection from the end; the other, $\frac{1}{3}$ projection from the body (N).

Oct. 18. 1 5. I can distinguish one upon the preceding projection very certainly (O).

Oct. 20. 21 26. I suspect the end of the preceding arm to be loaded with a satellite (P)

(H) The spot β. By calculation, at 11 h. 37′ 9″ it was 309°,2, or just following the 7th satellite, which appeared then upon the preceding arm in the shape of a small bright point.

(I) The spots γ and δ. The former at 6 h. 23′ 9″ was 217°,6, the latter 289°,9. δ is probably a spot upon the northern plane of the ring of a considerable degree of brightness, though but small in its dimensions, and at no great distance from the edge.

(K) The spot γ was by this time at 229°,0, and therefore in a situation to be easily perceived.

(L) The spot γ 247°,2.   (M) The spot γ 248°,9.

(N) The spot α, at 11 h. 1′ 23″, was at 217°,2; and ι was also visible, being at 304°,3. This spot is probably a very small one, on the northern plane of the ring, at some distance from the edge.

(O) The spot α was now at 219°,4, and being very bright could be distinguished easily.   (P) The spot α, at 7 h. 19′ 7″, was at 290°,7.

21 56. The preceding arm is certainly loaded with one or two satellites, or is more knotty than I have ever observed it to be. The weather is very beautiful (Q).

Oct. 30. 20 53. I suppose the 7th to be upon the following arm ¼ dia. of ♄ f. the body (R).

23 55. The 7th sat. ⅜ dia. of ♄ p. the body, or very near to the end of the p. arm, in the shape of a protuberant point (S).

0 1. I see it so well that there is no doubt but that it is a satellite (T).

0 42. The 7th is upon the p. arm, but a little nearer than it was before (V).

0 47. The 7th sat. ⅜ dia. of ♄ p. the body (W).

Oct. 31. 21 13. The 7th sat. ⅜ dia. of ♄ p. the body (X).

21 43. The 7th sat. is brighter than usual; I see it with great ease, notwithstanding the moon is almost at the full. It is brighter now than the 6th (Y).

22 11. The 7th is drawn nearer to the body of ♄. Flying clouds prevent estimations of the distance (Z).

23 13. The 7th is now no longer visible (A).

Nov. 2. 22 14. The 7th sat. ⅜ dia. of ♄ p. the body, it is upon the arm (B).

(Q) The spot α was now at 307°,8; and at the same time the spot β being come on as far as 219°,3, was therefore visible.

(R) The spot δ, at 6 h. 6′ 57″ was at 40°,3.

(S) The spot α, at 9 h. 8′ 28″, was at 272°,4.

(T) It was now at 275°,8.

(V) At 299°,1.   (W) At 302°,0.

(X) The spot α, at 6 h. 22′ 59″, was 278°,4.

(Y) It was now at 295°,5.

(Z) At 305°,7.   (A) At 346°,7.

(B) The spot ι, at 7 h. 15′ 58″, was at 235°,6.

22 53. The 7th appears to be full ¼ dia. of ♄ p. the body; but hazy weather (C).

23 13. The 7th fat. ¼ dia. of ♄ p. the body (D).

o 8. The following arm contains a lucid point near the end of it (E).

o 16. The preceding arm feems to be loaded with two fmall points towards the end (F).

Nov. 4. 22 14. The 7th fat. I think, is between the 1ft and 6th, but I cannot be fure (G).

22 27. I cannot perceive the 7th fat. where I fufpected it (H).

23 47. The f. arm about ¼ dia. of ♄ from the body contains a fmall lucid point (I).

23 54. I fee the point on the f. arm fo well that I have not much doubt but that it is a fatellite (K).

Nov. 7. 22 9. At the end of the p. arm is a place that is brighter than nearer to the body (L).

23 12. The preceding arm has ftill the appearance of a fmall protuberant point towards the fouth, near the end of the arm (M).

Nov. 8. 23 40. There is a protuberant point on the preceding arm befides the 7th fat.; fo that at prefent I cannot tell whether the fatellite be the neareft or fartheft of them (N).

(C) At 257°,8.   (D) At 269°,1.

(E) The fpot δ, at 84°,4.   (F) The fpot ι, at 305°,0.

(G) The fpot ι, at 7 h. 8′ 7″, was at 71°,0, which agrees with the place, and it might be the fuppofed fatellite.   (H) At 78°,3.

(I) The fpot α, at 8 h. 40′ 51″, was at 36°,7.

(K) It was now at 40°,7.

(L) The fpot α, at 6 h. 51′ 21″, was at 274°,0.

(M) It was at 309°,8.

(N) The fpot δ, at 8 h. 18′ 11″, was at 294°,4.

Nov.

Nov. 10. 21 35. The following arm ¼ dia. of ♄ from the body contains a bright point; perhaps an 8th satellite (O).

Nov. 25. 1 21. The p. arm is loaded (P).

Nov. 29. 0 38. There are two small luminous points on the p. arm (Q).

Dec. 5. 0 8. Upon the end of the p. arm appears to be a bright point (R).

0 10. The spot on the preceding arm is rather larger than the 6th satellite (S).

Dec. 16. 0 7. The end of the p. arm seems to be loaded with a satellite (T).

Dec. 24. 0 7. The p. arm contains a pretty bright point ¼ towards the end of it (V).

Dec. 25. 23 39. The p. arm very near the end is loaded with a sat. (W).

1 10. The p. arm is loaded very nearly at the far end of it, and a little towards the south (X).

1 37. The bright point is near the far end of the p. arm (Y).

The great accordance between the observed places of these spots and the calculated ones, seems to establish the rotation of the ring of Saturn on an axis so as hardly to leave any doubt upon the subject. The time of it, we have already seen, is 10 hours, 32 minutes, and 15,4 seconds. It may be objected,

(O) The spot δ, at 6 h. 5′ 40″, was at 59°,1.
(P) The spot ι, at 8 h. 52′ 10″₂ was at 68°,6.
(Q) The spot β, at 7 h. 53′ 35″, was at 259°,6.
(R) The spot ι, at 7 h. 0′ 7″, was at 283°,8.
(S). It was now at 285°,0.
(T) The spot ι, at 6 h. 15′ 57″, was at 277°,4.
(V) The spot α, at 5 h. 44′ 33″, was at 251°,6.
(W) The spot β, at 5 h. 12′ 42″, was at 244°,8.
(X) It was now at 296°,0.　　　　　(Y) And now at 311°,4.

that

that many of the obſervations are ſuch as would alſo agree with other aſſignable periods, eſpecially when the numbers of ſpots is ſo conſiderable as five; but the moſt material obſervations, which are thoſe on the ſpot *a*, ſetting aſide all the reſt, ſeem alone to amount to a proof not only of a rotation of the ring, but of the time in which it is performed.

It may be expected, that having now ſufficiently examined the whole ſeries of obſervations of the laſt new ſatellites, we can give their periodical times and diſtances more accurately than before. The times, indeed, are full as well aſcertained as we can expect to have them: for on calculating ſix ſatellites by my tables back to Aug. 19 d. 12 h. 19′ 56″, 1787, we find their places 341°,1 the 5th; 10°,6 the 4th; 211°,1 the 3d; 158°,9 the 2d; 80°,2 the 1ſt; and 288°,8 the 6th. And my journal contains the fulleſt aſſurance that they were thus ſituated at the time for which this calculation is made. We may therefore fix the period of the ſixth at 1 d. 8 h. 53′ 8″,9. The 7th ſatellite can only be traced back as far as the 8th of Sept. 1789; ſo that its revolution will require at leaſt another ſeaſon to come to ſome degree of accuracy, till when we ſhall ſtate it at 22 h. 37′ 22″,9.

The diſtance of theſe ſatellites, deduced from calculation, depends intirely upon the time and diſtance of the 4th, which is the ſatellite that has been uſed. In order to obtain more accuracy in theſe elements, I have applied myſelf to meaſuring the diſtance of the 4th ſatellite in thoſe moments which were moſt favourable for the purpoſe. It is well known that this ſubject, on account of the quantity of matter in Saturn, to be deduced from the periodical times and diſtances of the ſatellites, is of conſiderable importance to aſtronomers; I ſhall

therefore

therefore defer a full investigation of it till I can have an opportunity of calculating a great number of measures, not only of the 4th and 5th, but also of the other satellites which I have already by me, and still intend next season to take. Mean while, having brought the measures of the 30th of November, which seem to me to be very good ones, to the mean distance of Saturn from the sun, I find they give the distance of the 4th satellite from Saturn 3′ 8″,918. In reducing these measures to the mean distance, I have used the new tables of M. DE LAMBRE for Saturn, and MAYER's for the sun.

Admitting therefore the above quantity as the distance, and 15 d. 22 h. 41′ 13″,4 as the period of the 4th satellite, we compute that the distance of the 6th from the center of Saturn is 36″,7889; and that of the 7th, 28″,6689.

Tables for the seven satellites of Saturn.

Epochs of the mean longitude of the satellites.

Years.	5. sat. Deg.dec	4. sat. Deg. dec.	3. sat. Deg. dec.	2. sat. Deg. dec.	1. sat. Deg. dec.	6. sat. Deg. dec.	7. sat. Deg. dec.
1787	335,91	149,16	87,21	272,18	176,46	269,31	307,07
1788	196,84	132,41	93,86	173,95	131,91	307,48	65,02
1789	53,23	93,09	20,82	304,19	256,66	82,92	161,00
1790	269,63	53,77	307,78	74,43	21,41	218,36	256,98
1791	126,02	14,45	234,74	204,68	146,16	353,81	352,97
1792	346.95	357.70	241.39	106.45	101.61	31.98	110.92
1793	203.34	318.37	168.35	236.69	226.36	157.42	206.90
1794							
1795							
1796							
1797							
1798							

Saturnicentric

Saturnicentric motion of the satellites in months.						
7	6	5	4	3	2	1
5th.	4th.	3d.	2d.	1st.	6th.	7th.
Months Deg.dec	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.
January 000,00	000,00	000,00	000,00	000,00	000,00	000,00
Februa. 140,68	339,89	310,40	117,58	151,64	224,54	320,81
March 267,75	252,05	21,73	200,56	91,18	20,9	215,73
April 48,43	231,95	332,13	318,14	242,81	245,45	176,54
May 184,57	189,26	202,84	304,19	203,75	207,27	115,39
June 325,25	169,16	153,24	61,77	355,39	71,81	76,20
July 101,39	126,47	23,94	47,82	316,33	33,63	15,05
August 242,07	106,37	334,34	165,40	107,96	258,17	335,86
Septem. 22,75	86,26	284,74	282,98	259,60	122,72	296,67
October 158,89	43,58	155,45	269,03	220,54	84,54	235,52
Novem. 299,57	23,47	105,85	26,61	12,17	309,08	196,33
Decem. 75,71	340,78	336,56	12,66	333,11	270,90	135,17

In the months January and February of a biffextile year fubtract 1 from the number of days given.

I Motion

	Motion of the satellites in days.						
	5th.	4th.	3d.	2d.	1st.	6th.	7th.
Days	Deg. Dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.
1	4,54	22,58	79,69	131,53	190,70	262,73	21,96
2	9,08	45,15	159,38	263,07	21,40	165,45	43,92
3	13,61	67,73	239,07	34,60	212,09	68,18	65,88
4	18,15	90,31	318,76	166,14	42,79	330,91	87,85
5	22,69	112,89	38,45	297,67	233,49	233,64	109,81
6	27,23	135,46	118,14	69,21	64,19	136,36	131,77
7	31,77	158,04	197,83	200,74	254,89	39,09	153,73
8	36,30	180,62	277,52	332,28	85,58	301,82	175,69
9	40,84	203,19	357,21	103,81	276,28	204,55	197,65
10	45,38	225,77	76,90	235,35	106,98	107,27	219,62
11	49,92	248,35	156,59	6,88	297,68	10,00	241,58
12	54,46	270,93	236,28	138,42	128,38	272,73	263,54
13	58,99	293,50	315,97	269,95	319,07	175,45	285,50
14	63,53	316,08	35,66	41,49	149,77	78,18	307,46
15	68,07	338,66	115,35	173,02	340,47	340,91	329,42
16	72,61	1,24	195,04	304,56	171,17	243,64	351,39
17	77,15	23,81	274,74	76,09	1,87	146,36	13,35
18	81,69	46,39	354,43	207,63	192,56	49,09	35,31
19	86,22	68,97	74,12	339,16	23,26	311,82	57,27
20	90,76	91,54	153,81	110,70	213,96	214,54	79,23
21	95,30	114,12	233,50	242,23	44,66	117,27	101,19
22	99,84	136,70	313,19	13,77	235,35	20,00	123,16
23	104,38	159,28	32,88	145,30	66,05	282,73	145,12
24	108,91	181,85	112,57	276,84	256,75	185,45	167,08
25	113,45	204,43	192,26	48,37	87,45	88,18	189,04
26	117,99	227,01	271,95	179,91	278,15	350,91	211,00
27	122,53	249,58	351,64	311,44	108,84	253,64	232,96
28	127,07	272,16	71,33	82,98	299,54	156,36	254,92
29	131,60	294,74	151,02	214,51	130,24	59,09	276,89
30	136,14	317,32	230,71	346,05	320,94	321,82	298,85
31	140,68	339,89	310,40	117,58	151,64	224,54	320,81
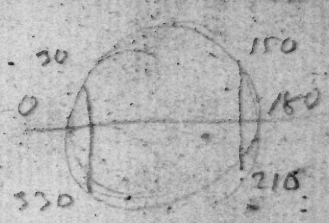
Motion of the satellites in hours.

Hours.	5th. Deg. dec.	4th. Deg. dec.	3d. Deg. dec.	2d. Deg. dec.	1st. Deg. dec.	6th. Deg. dec.	7th. Deg. dec.
1	0,19	0,94	3,32	5,48	7,95	10,95	15,92
2	0,38	1,88	6,64	10,96	15,89	21,89	31,83
3	0,57	2,82	9,96	16,44	23,84	32,84	47,75
4	0,76	3,76	13,28	21,92	31,78	43,79	63,66
5	0,95	4,70	16,60	27,40	39,73	54,73	79,58
6	1,13	5,64	19,92	32,88	47,67	65,68	95,49
7	1,32	6,58	23,24	38,36	55,62	76,63	111,41
8	1,51	7,53	26,56	43,84	63,57	87,58	127,32
9	1,70	8,47	29,88	49,33	71,51	98,52	143,24
10	1,89	9,41	33,20	54,81	79,46	109,47	159,15
11	2,08	10,35	36,52	60,29	87,40	120,42	175,07
12	2,27	11,29	39,84	65,77	95,35	131,36	190,98
13	2,46	12,23	43,17	71,25	103,29	142,31	206,90
14	2,65	13,17	46,49	76,73	111,24	153,26	222,81
15	2,84	14,11	49,81	82,21	119,19	164,20	238,73
16	3,03	15,05	53,13	87,69	127,13	175,15	254,64
17	3,21	15,99	56,45	93,17	135,08	186,10	270,56
18	3,40	16,93	59,77	98,65	143,02	197,05	286,47
19	3,59	17,87	63,09	104,13	150,97	207,99	302,39
20	3,78	18,81	66,41	109,61	158,91	218,94	318,30
21	3,97	19,75	69,73	115,09	166,86	229,89	334,22
22	4,16	20,70	73,05	120,57	174,81	240,83	350,13
23	4,35	21,64	76,37	126,05	182,75	251,78	6,05
24	4,54	22,58	79,69	131,53	190,70	262,73	21,96

Motion

Motion of the satellites in minutes.						
5th.	4th.	3d.	2d.	1st.	6th.	7th.
Min. Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.
1 0,00	0,02	0,06	0,09	0,13	0,18	0,27
2 0,01	0,03	0,11	0,18	0 26	0,36	0,53
3 0,01	0,05	0,17	0,27	0,40	0,55	0,80
4 0,01	0,06	0,22	0,37	0,53	0,73	1,06
5 0,02	0,08	0,28	0,46	0,66	0,91	1,33
6 0,02	0,09	0,33	0,55	0,79	1,09	1,59
7 0,02	0,11	0,39	0,64	0,93	1,28	1,86
8 0,03	0,13	0,44	0,73	1,06	1,46	2,12
9 0,03	0,14	0,50	0,82	1,19	1,64	2,39
10 0,03	0,16	0,55	0,91	1,32	1,82	2,65
11 0,04	0,17	0,61	1,00	1,46	2,01	2,92
12 0,04	0,19	0,66	1,10	1,59	2,19	3,18
13 0,04	0,20	0,72	1,19	1,72	2,37	3,45
14 0,05	0,22	0,77	1,28	1,85	2,55	3,71
15 0,05	0,24	0,83	1,37	1,99	2,74	3,98
16 0,05	0,25	0,89	1,46	2,12	2,92	4,24
17 0,06	0,27	0,94	1,55	2,25	3,10	4,51
18 0,06	0,28	1,00	1,64	2,38	3,28	4,78
19 0,06	0,30	1,05	1,73	2,52	3,47	5,04
20 0,07	0,31	1,11	1,83	2,65	3,65	5,31
21 0,07	0,33	1,16	1,92	2,78	3,83	5,57
22 0,07	0,34	1,22	2,01	2,91	4,01	5,84
23 0,08	0,36	1,27	2,10	3,05	4,20	6,10
24 0,08	0,38	1,33	2,19	3,18	4,38	6,37
25 0,08	0,39	1,38	2,28	3,31	4,56	6,63
26 0,09	0,41	1,44	2,37	3,44	4,74	6,90
27 0,09	0,42	1,49	2,47	3,57	4,93	7,16
28 0,09	0,44	1,55	2,56	3,71	5,11	7,43
29 0,10	0,45	1,60	2,65	3,84	5,29	7,69
30 0,10	0,47	1,66	2,74	3,97	5,47	7,96

Motion

	7	6	5	4	3	2	1
	Motion of the satellites in minutes.						
	5th.	4th.	3d	2d.	1ft.	6th.	7th.
Min.	Deg. Dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.	Deg. dec.
31	0,10	0,49	1,72	2,83	4,10	5,66	8,22
32	0,11	0,50	1,77	2,92	4,24	5,84	8,49
33	0,11	0,52	1,83	3,01	4,37	6,02	8,75
34	0,11	0,53	1,88	3,10	4,50	6,20	9,02
35	0,12	0,55	1,94	3,20	4,63	6,39	9,29
36	0,12	0,56	1,99	3,29	4,77	6,57	9,55
37	0,12	0,58	2,05	3,38	4,90	6,75	9,82
38	0,13	0,60	2,10	3,47	5,03	6,93	10,08
39	0,13	0,61	2,16	3,56	5,16	7,12	10,35
40	0,13	0,63	2,21	3,65	5,30	7,30	10,61
41	0,14	0,64	2,27	3,74	5,43	7,48	10,88
42	0,14	0,66	2,32	3,83	5,56	7,66	11,14
43	0,14	0,67	2,38	3,93	5,69	7,85	11,41
44	0,15	0,69	2,43	4,02	5,83	8,03	11,67
45	0,15	0,71	2,49	4,11	5,96	8,21	11,94
46	0,15	0,72	2,55	4,20	6,09	8,39	12,20
47	0,16	0,74	2,60	4,29	6,22	8,58	12,47
48	0,16	0,75	2,66	4,38	6,36	8,76	12,73
49	0,16	0,77	2,71	4,47	6,49	8,94	13,00
50	0,17	0,78	2,77	4,57	6,62	9,12	13,27
51	0,17	0,80	2,82	4,66	6,75	9,30	13,53
52	0,17	0,82	2,88	4,75	6,88	9,49	13,80
53	0,17	0,83	2,93	4,84	7,02	9 67	14,06
54	0,18	0,85	2,99	4,93	7,15	9,85	14,33
55	0,18	0,86	3,04	5,02	7,28	10,03	14,59
56	0,18	0,88	3,10	5,11	7,41	10,22	14,86
57	0,19	0,89	3,15	5,20	7,55	10,40	15,12
58	0,19	0,91	3,21	5,30	7,68	10,58	15,39
59	0,19	0,93	3,27	5,39	7,81	10,76	15,65
60	0,20	0,94	3,32	5,48	7,94	10,95	15,92

Table

Table of the rotation of the ring of Saturn.

Epochs for 1789.		Motion of the spots in days, hours, and minutes.							
		Days	Deg.dec	Hou.	Deg.dec	Min.	Deg.dec	Min.	Deg.dec
Spot α	271,5	1	99,92	1	34,16	1	0,57	31	17,65
β	183,0	2	199,84	2	68,33	2	1,14	32	18,22
γ	70,2	3	299,76	3	102,49	3	1,71	33	18,79
δ	142,5	4	39.68	4	136,65	4	2,28	34	19,36
ε	358,6	5	139,60	5	170,81	5	2,85	35	19,93
		6	239,52	6	204,98	6	3,42	36	20,50
Motion of the spots in Months.		7	339,44	7	239,14	7	3,99	37	21,07
		8	79,36	8	273,30	8	4,56	38	21,64
Months.	Deg. dec.	9	179,28	9	307,46	9	5,12	39	22,21
January	000,00	10	279,20	10	341,63	10	5,69	40	22,78
February	217,52	11	19,12	11	15,79	11	6,26	41	23,35
March	135,28	12	119,04	12	49,95	12	6,83	42	23,91
April	352,80	13	218,96	13	84,11	13	7,40	43	24,48
May	110,40	14	318,88	14	118,28	14	7,97	44	25,05
June	327,92	15	58,80	15	152,44	15	8,54	45	25,62
July	85,52	16	158,72	16	186,60	16	9,11	46	26,19
August	303,04	17	258,64	17	220,76	17	9,68	47	26,76
September	160,56	18	358,56	18	254,93	18	10,25	48	27,33
October	278,16	19	98,48	19	289,09	19	10,82	49	27,90
November	135,68	20	198,40	20	323,25	20	11,39	50	28,47
December	253,28	21	298,32	21	357,41	21	11,96	51	29,04
		22	38,24	22	31,59	22	12,53	52	29,61
		23	138,16	23	65,75	23	13,10	53	30,18
		24	238,08	24	99,91	24	13,67	54	30,75
		25	338,00			25	14,24	55	31,32
		26	77,92			26	14,80	56	31,89
		27	177,84			27	15,37	57	32,46
		28	277,76			28	15,94	58	33,03
		29	17,68			29	16,51	59	33,59
		30	117,60			30	17,08	60	34,16
		31	217,52						

Example

Example of the use of the tables.

Let it be required to calculate the apparent place of the feven fatellites for 1789, Oct. 18. 7 h. 51′ 54″, to the neareſt minute of time and to tenths of a degree.

	5th.	4th.	3d.	2d.	1ſt.	6th.	7th.
1789	53,23	93,09	20,82	304,19	256,66	82,92	161,00
Oct.	158,89	43,58	155,45	269,03	220,54	84,54	235,52
18	81,69	46,39	354,43	207,63	192,56	49,09	35,31
7	1,32	6,58	23,24	38,36	55,62	76,63	111,41
52	0,17	0,82	2,88	4,75	6,88	9,49	13,80
* ♄	12,58	12,58	12,58	12,58	12,58	12,58	12,58
	307,9	203,0	209,4	116,5	24,8	315,3	209,6

The fituation of the ſpot α calculated for July 28. 13 h. 53′ 39″; β for Sept. 16. 7 h. 45′ 48″; ε for Nov. 2. 7 h. 15′ 58″.

1789, α		β		ε	
July	271,5	Sept.	183,0	Nov.	358,6
28	85,52	16	160,56	2	135,68
13	277,76	7	158,72	7	199,84
54	84,11	46	239,14	16	239,14
♄	30,75	♄	26,19	♄	9,11
	7,20		10,45		13,18
	36,8		58,1		235,6

* The quantity marked ♄ 12°,58, which is applied to every one of the ſatellites, is the complement of 11ˢ 17° 25′, or geocentric place of Saturn, taken from the Nautical Almanac, for midnight of the required day, and to the neareſt minute, which is ſufficiently exact. This complement, or 12° 35′ in conformity with the tables, is reduced to decimals of a degree 12°,58.
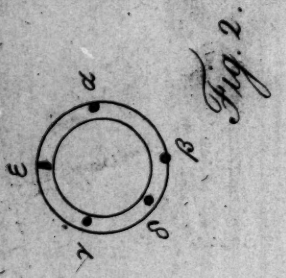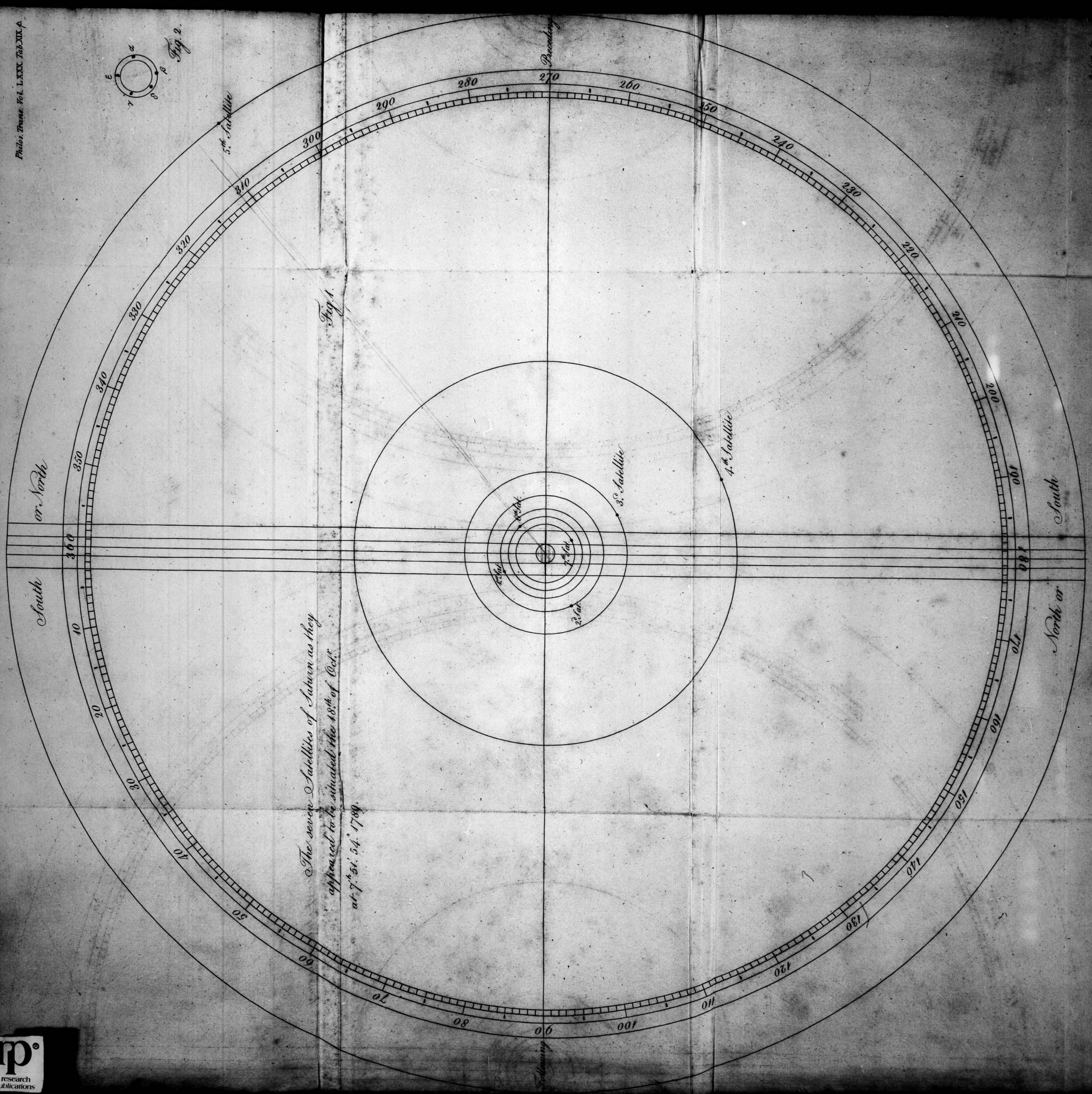
Fig. 2.

5.th Satellite

Preceding

290   280   270   260
300   250
310   240
320   230

Fig. 1.

330   220
340   210
350
North   200

360   190
South

The seven Satellites of Saturn as they
appeared to be situated the 18.th of Octr.
at 7.h 51' 54" 1789.

4.th Satellite

3.d Satellite

North or
South

10
20
30
40
50
60   70   80   90   100   110

Following